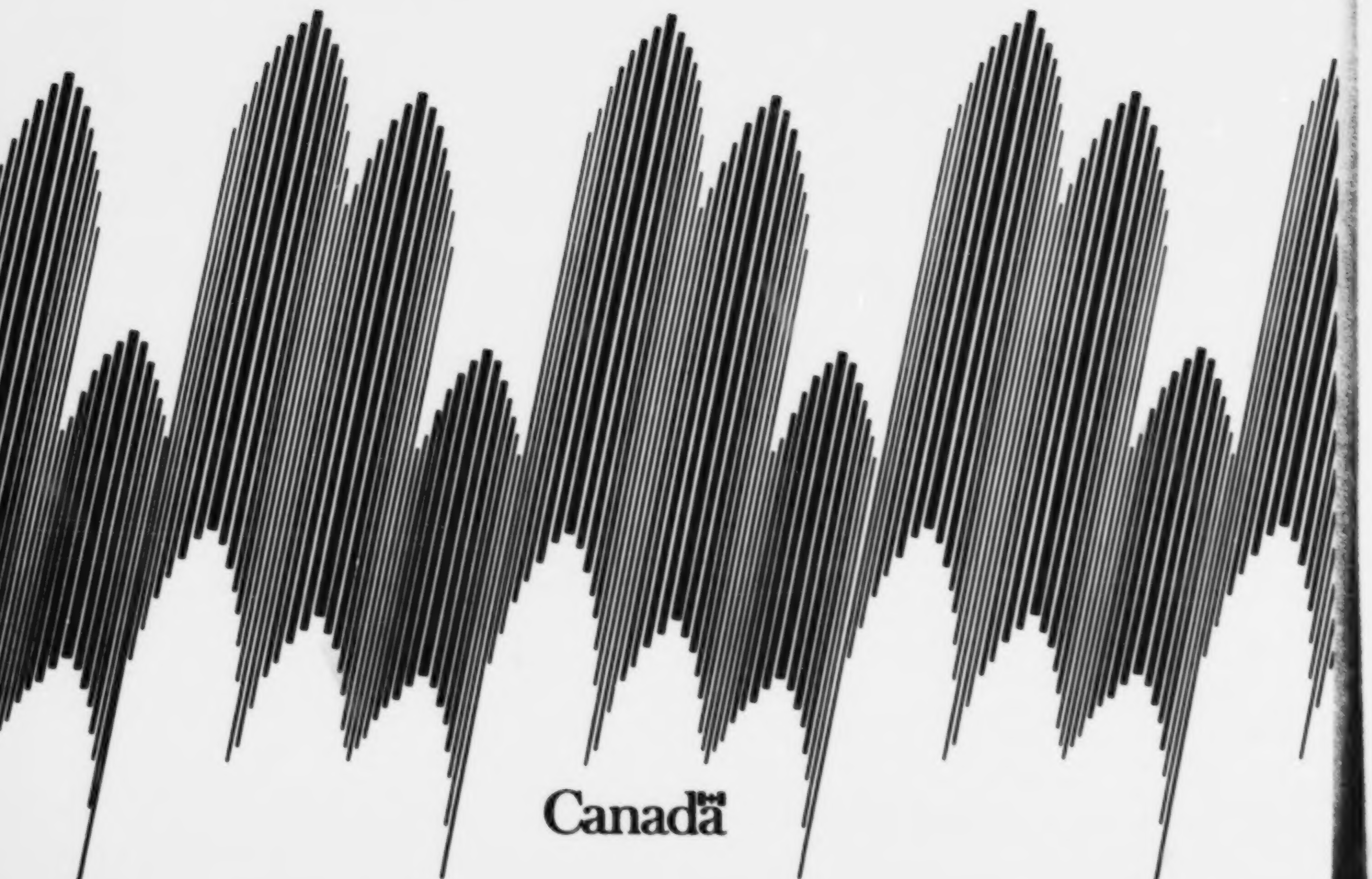
Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

REMOTE COMMUNITY DEMONSTRATION PROGRAM

Phase 1

Report summaries



Canada

PREPARED FOR:
The Remote Community Demonstration Program
Renewable Energy Division
Energy, Mines and Resources Canada
Ottawa, Ontario

March,1986

The enclosed report summaries were extracted from Phase I study reports funded with contributions from the Remote Community Demonstration Program of Energy, Mines and Resources Canada (EMR). Distribution of this report by EMR does not necessarily signify that the contents reflect the views and policies of EMR. Mention of trade names and commercial products does not constitute recommendation or endorsement for use.

This manual is also available in French

TABLE OF CONTENTS

Page

Introduction v

Phase I Study Matrix vii

Phase I Studies by Topic/Region/Study Number ix
    Section 1 - Overviews 1
    Section 2 - Alternative Methods of Supply 35
    Section 3 - Conservation of Energy 261
    Section 4 - ENEROPTIONS CASE STUDIES 353

Phase I Studies by Study Number/Title xiii

Maps Showing Locations of Remote Communities xvii

CREO and RCDP-HQ Addresses/Phone Numbers xxix

REMOTE COMMUNITY DEMONSTRATION PROGRAM, PHASE I (STUDIES)

INTRODUCTION

This binder contains executive summaries of the 81 studies prepared under Phase I of the Remote Community Demonstration Program (RCDP) of Energy, Mines and Resources Canada (EMR). In this phase, which ran from October 1982 to September 1985, the Program contracted a series of overview studies and contributed to studies done by or for remote communities and agencies responsible for energy supply in remote communities. The overview studies were to provide a current and projected information base on remote community energy supply and demand. The contribution studies were to identify and assess energy conservation and alternative energy supply opportunities in specific communities.

The studies relate to approximately 370 remote communities in Canada that meet the Program's definition: in the Yukon or NWT; or, if in the provinces, not on a provincial hydro grid and without access to natural gas, and having at least 10 principal residences, and five years of planned life remaining. No remote communities have been identified in New Brunswick, Nova Scotia or Prince Edward Island.

EMR is distributing this binder in order to disseminate information on opportunities for conservation and alternative technologies in remote communities to those who could benefit from that information. It should be noted that the contents do not necessarily reflect the views and policies of the Department. Mention of trade names and commercial products does not constitute recommendation or endorsement for use.

The summaries are arranged in the following order:

Section 1:	Energy overview of Canada's remote communities. Energy overviews of remote communities by region (except NWT).
Section 2:	Studies on alternative-to-oil energy supply based on: small hydro, wind, wood, peat, coal, tides, geothermal heat, methanol, waste oil and local natural gas.
Section 3:	Studies on energy conservation. These include: heat recovery and more efficient use of diesels; energy audits, retrofit of existing buildings, energy training and new house design.

Two indexes to the summaries are provided. The first lists the studies by topic and region. The number in brackets after each abbreviated title is the RCDP report number for the study. The second index lists full report titles by report number. While some studies in Sections 2 and 3 cover more than one topic, summaries have been arranged according to the report's major topic. Cross references are provided.

The RCDP studies show that for many remote communities there are technically and economically feasible ways to reduce consumption of energy in general, and oil in particular. Virtually every remote community could benefit from the conservation techniques described. In the realm of alternatives, the studies suggest that many communities do indeed have a technically feasible alternative to oil that could also be economically worth pursuing.

Section 4 of the binder contains the EnerOptions information package for the remote community sector as prepared under the Conservation and Renewable Energy Demonstration Agreements (CREDA). This involves two overviews and 15 case studies of the most successful CREDA demonstrations applicable to remote communities.

For additional information on the RCDP studies or CREDA projects, please contact one of the EMR Conservation and Renewable Energy Offices or RCDP Headquarters. A list of these offices is provided on page xxix.

August 16, 1985

PHASE I STUDIES BY REGION/TOPIC (EX[illegible]G OVERVIEW STUDIES)

Note: The numbers placed after
the dashes represent report
numbers. For letters, see next page.

TOPIC	YT	NWT	B.C.	ALTA	SASK	MAN	ONT	QUE	NFLD	TOTAL
ALTERNATIVES										
Small Hydro	Dawson* -53 Morley R. -16	NCPC -76	Bamfield/ -22 Bella Bella Cassiar -44 Esperanza -19 Moses Inlet -18 Seymour Arm -14 See notes A&B	Fox Lake/ John D'Or Prairie (Vermilion Falls) -58	Southend -38	Brochet/Lac Brochet -48 North Central -15		Waskaganish (hydro) -20 Waskaganish^{C} (Comparative) -63 See note D	L'Anse au Clair -67 Mary's Harbour -12 Rigolet -50	17
Wind		Territory^{E} -57	Kitkatla -23				Mud R. -61	Is. Madeleine -47 (wind farm) Is. Madeleine (domestic) -64	Labrador -69 St. Anthony -68 S. Coast Nfld -45	8
Wood		Fort Smith -74 Rae-Edzo -28 25 commun's -73	Fort Ware -40 Qu. Charlotte Is. -34	Trout L/ Garden C -77	Brabant Lake -27		Province-^{F} wide -39	Eastmain/ Waskaganish/ Wemindji -33 See notes C&D	Cartwright/ -66 Black Tickle N. Nfld/ Coastal Lab -49 Province-wide -70 Roddickton -48	13
Peat		Hay R/ -36 Yellowknife			Deschambault Lake -21		Cat Lake -30			3
Geothermal	Mayo -55		Hot Springs Cove -51							2
Tidal			Qu. Charlotte Is. -29							1
Coal		Pond Inlet -10								1
Methanol		Territory-wide -56								1
Waste Oil		Hay R. -72								1
Local Natural Gas				Chipewyan L. -35						1
										48
CONSERVATION										
Heat recovery/ Diesel efficiency	Old Crow -25	Grise Fiord/ Pond Inlet -9 Inuvik -79 Territory-wide -80	Atlin^{A} -41		Wollaston -37		Big Trout L/ Pikangikum/ Sandy Lake-26 See also note G		Pinsent's Arm Norman Bay ^{H} -52	8
Energy audit of buildings/ Retrofit suggestions/ Energy training	Beaver Creek -54	S. Mackenzie -42 Lwr Mackenzie -11	Hartley Bay^{B} -32	Fort Chipewyan -13	Fond du Lac -46 N'n Lights -59 Province-wide institutions -78	Island Lake TC -75	Armstrong -17 Attawapiskat -31	Kativik -71 Wemindji -62 Weymontachie/^{D} Obedjiwan -65		14
Energy audits/ New house designs						MKO -60	Windigo^{G} -24			2
										24
TOTAL	5	14	12	4	7	4	7	8	11	72

NOTES

A) BC: Atlin
Also reviews small hydro potential.

B) BC: Hartley Bay
Reviews alternative energy options - most promising is small hydro.

C) Waskaganish (Comparative)
Analyzes demand and compares, among other options, small hydro, wood furnaces and wind, wood gasifier.

D) Weymontachie/Obedjiwan
Analyzes demand, recommends building retrofits and compares, among other options, small hydro, wood, wind, solar, grid extension.

E) NWT:
Wind/hydro study.

F) Ontario Biomass:
Also reviews peat potential.

G) Windigo.
Also recommends retrofit measures for houses and community buildings, heat recovery for two communities served by diesel, and wood-oil heating for one school.

H) Nfld: Pinsent's Arm/Norman Bay
Cycle charge diesel efficiency. Also reviews photovoltaic and wind potential.

PHASE I STUDIES BY TOPIC/REGION/STUDY NUMBER

	STUDY NO.	PAGE
SECTION 1 - OVERVIEWS		
National overview	0	1
Regional overviews		
-Yukon	1	3
-British Columbia	2	7
-Alberta	3	9
-Saskatchewan	4	11
-Manitoba	5	13
-Ontario	6	15
-Quebec	7	29
-Newfoundland	8	33
SECTION 2 - ALTERNATIVE METHODS OF SUPPLY		
Small hydro		
-Yt -Dawson (Klondike North Fork)	53	35
-Morley River	16	39
-NWT -NCPC Feasibility	76 & 76A	41 - 47
-BC -Bamfield/Bella Bella	22	53
-Cassiar	44	65
-Esperanza	19	69
-Moses Inlet	18	71
-Seymour Arm	14	73
-Alta-Fox Lake/John D'Or Prairie (Vermilion Falls)	58	75
-Sask-Southend (Whitesand Dam)	38	79
-Man -Brochet/Lac Brochet	43	83
-North Central area	15	101
-Que -Waskaganish (hydro study)	20	109
-Waskaganish (comparative study)	63	111
-Nfld-L'Anse au Clair	67	115
-Mary's Harbour	12	121
-Rigolet	50	123
Wind		
NWT - Territory-wide	57	125
BC -Kitkatla	23	129
Ont -Mud River	61	133
Que -Iles de la Madeleine (IREQ)	47	135
-Iles de la Madeleine (ADELIM)	64	137
Nfld -Labrador sites	69	141
-St. Anthony	68	149
-South Coast of Newfoundland	45	153
Wood		
NWT -Fort Smith	74	159
-Rae-Edzo	28	165
-25 communities	73	169
BC -Fort Ware	40	171
-Queen Charlotte Islands	34	183

	STUDY NO.	PAGE
Alta - Trout Lake/Garden Creek	77	189
Sask - Brabant Lake	27	191
Ont - Province-wide	39	193
Que - Eastmain/Waskaganish/Wemindji	33	207
Nfld - Cartwright/Black Tickle	66	211
- Northern Newfoundland/coastal Labrador	49	215
-Province-wide	70	217
- Roddickton	48	223

Peat

NWT -Hay River/Yellowknife	36	229
SAsk -DEschambault Lake	21	231
Ont -Cat Lake	30	233

Geothermal

YT -Mayo	55	237
BC -Hot Springs Cove	51	239

Tidal

BC -Queen Charlotte Islands	29	241

Coal

NWT -Pond Inlet	10	245

Methanol

NWT -Territory-wide	56	253

Waste oil

NWT -Hay River	72	255

Local Natural gas

Alta -Chipewyan Lake	35	259

SECTION 3 - CONSERVATION OF ENERGY

Heat recovery/diesel efficiency

Yt -Old Crow	25	261
NWT -Grise Fiord/Pond Inlet	9	263
-Inuvik	79	265
-Territory-wide	80	269
BC -Atlin	41	273
Sask -Wollaston	37	275
Ont -Big Trout Lake/Pkangikum/Sandy Lake	26	279
Nfld -Pinsent's Arm/Norman Bay	52	289

Energy audit of buildings/retrofit suggestions/energy training

Yt -Beaver Creek	54	291
NWT -South Mackenzie	42	297
-Lower Mackenzie	11	299
BC -Hartley Bay	32	301
Alta -Fort Chipewyan	13	303
Sask -Fond du Lac	46	311
-Northern Lights School Division	59	313
-Province-wide (institutions)	78	317
Man -Island Lake communities	75	319

	STUDY NO.	PAGE
Ont -Armstrong	17	321
-Attawapiskat	31	323
Que -Kativik	71	327
-Wemindji	62	329
-Weymontachie/Obedjiwan	65	333
Energy audits/new house designs		
Man -MKO	60	339
Ont -Windigo	24	341
SECTION 4 - ENEROPTIONS CASE STUDIES	--	353

REMOTE COMMUNITY DEMONSTRATION PROGRAM
PHASE I STUDIES

Number	Title	Date	Page
RCDP/PDCE-0	Energy Overview of Canada's Remote Communities	Mar 85	1
RCDP/PDCE-1	Overview Study of the Potential for Yukon Communities to Reduce their Dependence on Oil	Jan 84	3
RCDP/PDCE-2	Energy Overview Study for Remote Communities in B.C.	1983	7
RCDP/PDCE-3	Energy Overview Study of Alberta's Remote Communities	Mar 83	9
RCDP/PDCE-4	Remote Saskatchewan Community Energy Overview Study	Mar 83	11
RCDP/PDCE-5	Energy Profiles for Manitoba Remote Communities	Jan 83	13
RCDP/PDCE-6	Remote Community Energy Use - Quebec Overview Study	1983	29
RCDP/PDCE-7	Newfoundland Region Overview Study	Dec 83	33
RCDP/PDCE-8	Energy Alternatives for Ontario Remote Communities: A Strategy and Implementation Plan	Jun 84	15
RCDP/PDCE-9	Heat Recovery Potential, Grise Fiord & Pond Inlet (NWT)	Aug 83	263
RCDP/PDCE-10	A Study to Determine Off-Oil Options for Pond Inlet (NWT)	Nov 83	249
RCDP/PDCE-11	Building Inventory and Energy Use Survey 1983 (NWT- Lower Mackenzie)	1983	299
RCDP/PDCE-12	Mary's Harbour Mini-hydro Development Feasibility Study (Newfoundland)	Dec 83	121
RCDP/PDCE-13	Community Energy Planning for Fort Chipewyan, Alberta	Jan 84	303
RCDP/PDCE-14	Evaluation of Electrical Supply Alternatives for Seymour Arm, B.C.	Mar 84	73
RCDP/PDCE-15	North Central Manitoba Electrification Study	Mar 84	101
RCDP/PDCE-16	Morley River Hydro (Yukon), A Conceptual Engineering Study & Economic Analysis	Feb 84	39
RCDP/PDCE-17	Energy Conservation Potential for Non-Residential Buildings, Armstrong, Ont.	Apr 84	321
RCDP/PDCE-18	Feasibility of Supplying Hydro Power to Moses Inlet Forestry Camp Under Contract (B.C.)	Mar 84	71
RCDP/PDCE-19	Small Hydro Feasibility Study for Esperanza, B.C.	Mar 84	69
RCDP/PDCE-20	Prefeasibility Study of Mini-hydro Potential in the Vicinity of Waskaganish, Quebec	Apr 84	109
RCDP/PDCE-21	An Examination of Alternative Sources of Energy for Deschambault, Sask.	Apr 84	231
RCDP/PDCE-22	Alternative Options for Supplying Electrical Power to Bamfield and Bella Bella, B.C.	Mar 84	53
RCDP/PDCE-23	Energy Conservation and Wind Energy Feasibility Study Kitkatla, B.C.	Apr 84	129
RCDP/PDCE-24	Energy Conservation and Oil Substitution Alternatives, Windigo Tribal Council Communities, Ont.	May 84	341
RCDP/PDCE-25	Waste Heat Utilization Feasibility Study, Old Crow, YT	Sep 84	261
RCDP/PDCE-26	Study of Alternative Generation and Waste Heat Use in Ontario Remote Communities	Aug 84	279
RCDP/PDCE-27	Heat from Wood, Brabant Lake, Sask.	Aug 84	191
RCDP/PDCE-28	Wood Heating Conversion Study, Rae Edzo NWT	May 84	165
RCDP/PDCE-29	Tidal Power Study, Queen Charlotte Islands B.C.	Jul 84	241
RCDP/PDCE-30	Peat Energy Feasibility Study, Cat Lake Indian Community, Ont.	Oct 84	233
RCDP/PDCE-31	Energy Conservation Through Thermal Upgrading of Buildings in Attawapiskat, Ont.	Aug 84	323

REMOTE COMMUNITY DEMONSTRATION PROGRAM
PHASE I STUDIES

Number	Title	Date	Page
RCDP/PDCE-32	Off-Oil Energy Generation and Conservation Opportunities for Remote Communities, with particular reference to Hartley Bay, BC.	Sep 83	301
RCDP/PDCE-33	Firewood Demand and Supply Study for Eastmain Wemindji and Waskaganish, Quebec	Sep 84	207
RCDP/PDCE-34	Biomass Utilization Study, Queen Charlotte Islands, B.C.	Oct 84	183
RCDP/PDCE-35	Energy Options for Chipewyan Lake, Alta	Oct 84	259
RCDP/PDCE-36	Feasibility of Fuel Peat Production and Utilization, Hay River and Yellowknife, NWT	Aug 84	229
RCDP/PDCE-37	Waste Heat Utilization Study, Wollaston, Sask.	Sep 84	275
RCDP/PDCE-38	Small Hydro Pre-Feasibility Study, Whitesand Control Dam, near Southend,Sask	Dec 84	79
RCDP/PDCE-39	Remote Biomass Assessment Study, Ontario	Nov 84	193
RCDP/PDCE-40	A Feasibility Study for a Wood-fired Steam Engine/Generator Set for Electricity Generation at Fort Ware, B.C.	Nov 84	171
RCDP/PDCE-41	Energy Alternatives for Atlin, B.C.	Oct 84	273
RCDP/PDCE-42	Building Inventory and Energy Use Survey, 1984 (NWT - South Mackenzie)	1984	297
RCDP/PDCE-43	Energy Alternatives Study, Brochet and Lac Brochet, Man	Oct 84	83
RCDP/PDCE-44	Review of Alternative Energy Sources and Electric Power Utility Proposal for Cassiar, B.C.	Dec 84	65
RCDP/PDCE-45	Wind Energy Conservation System, Prefeasibility Study, South Coast Region of Newfoundland	Dec 84	153
RCDP/PDCE-46	An Energy Overview Study for Fond-du-Lac, Sask.	Dec 84	311
RCDP/PDCE-47	Etude des vents en vue d'aider au choix d'emplacement d'une centrale éolienne, Iles de la Madeleine (Québec)	Déc 84	135
RCDP/PDCE-48	Biomass Utilization Study, Roddickton-Main Brook Region, Nfld.	Jan 85	223
RCDP/PDCE-49	Biomass Fuel Utilization Study in Northern Newfoundland and Coastal Labrador	Jan 85	215
RCDP/PDCE-50	Mini-hydro/Water Supply Feasibility Study for Rigolet, Labrador	Jan 85	123
RCDP/PDCE-51	Energy Conservation Options, Hot Springs Cove, B.C.	Feb 85	239
RCDP/PDCE-52	Alternative Energy Generation System for Pinsent's Arm and Norman Bay, Labrador, A Feasibility Study	Feb 85	289
RCDP/PDCE-53	Preliminary Study of Klondike North Fork Hydroelectric Redevelopment, Y.T.	Mar 85	35
RCDP/PDCE-54	Community Energy Plan, Beaver Creek, Y.T. and energy planning handbook for remote northern communities	Mar 85	291
RCDP/PDCE-55	Heat Pump Opportunities, Mayo, Y.T.	Mar 85	237
RCDP/PDCE-56	Small-scale Methanol Production and its Potential Application in NWT Communities	Mar 85	257
RCDP/PDCE-57	Investigation of the Viability of a Remote Wind/Hydroelectric Power Supply in the NWT	Mar 85	125
RCDP/PDCE-58	Prefeasibility Study of Hydroelectric Power Generation at Vermilion Falls, Alta	Mar 85	75

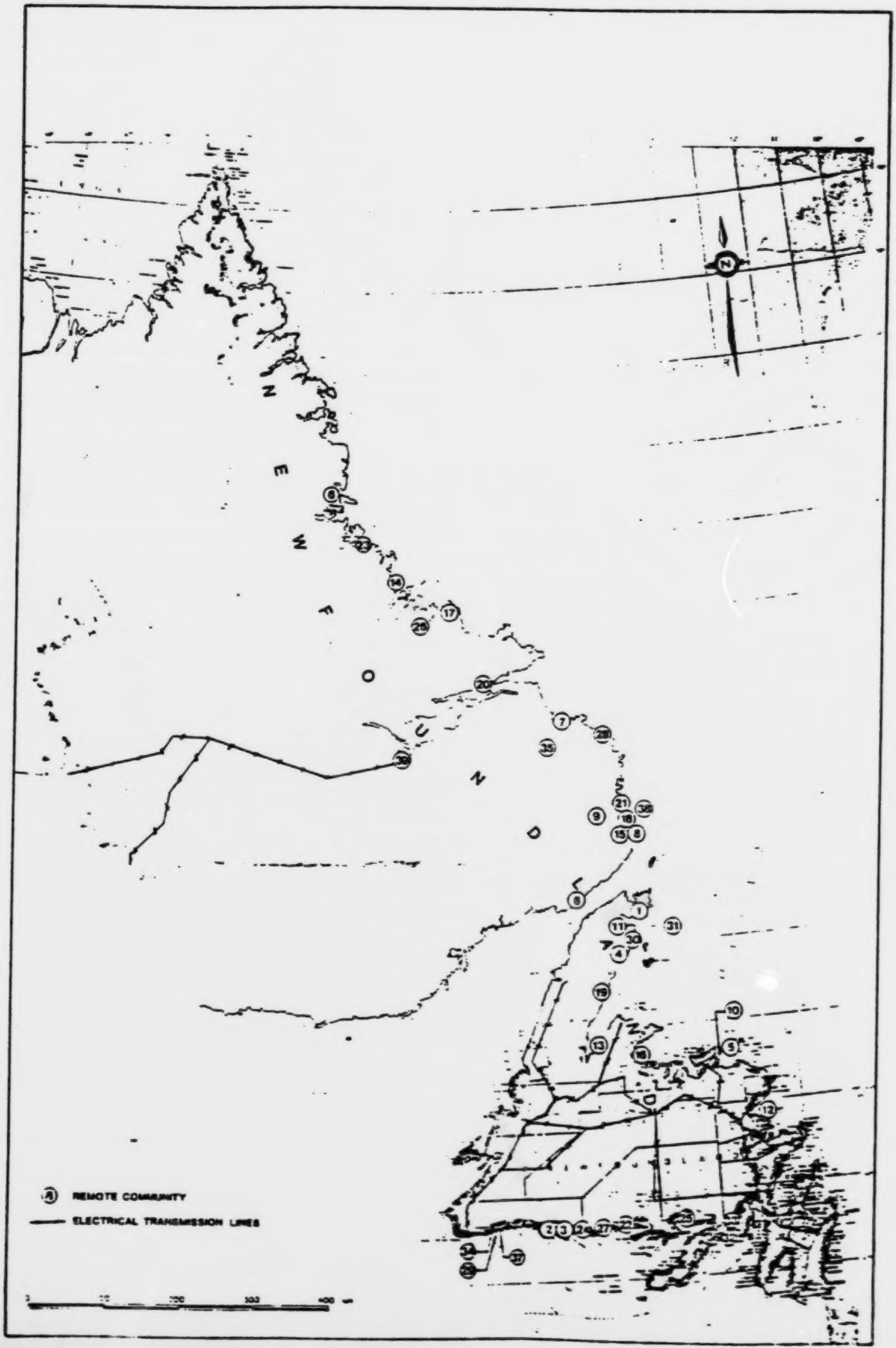
REMOTE COMMUNITY DEMONSTRATION PROGRAM
PHASE I STUDIES

Number	Title	Date	Page
RCDP/PDCE-59	Energy Conservation for Northern Saskatchewan Schools	Mar 85	313
RCDP/PDCE-60	Designs for Energy Efficient Housing in Northern Manitoba	Aug 85	339
RCDP/PDCE-61	Feasibility of Generating Electricity by a Wind/Diesel System in Mud River, Ontario	Mar 85	133
RCDP/PDCE-62	Energy Management Systems, Wemindji, Que.	Mar 85	329
RCDP/PDCE-63	A Comparative Study of Energy Systems for Waskaganish, Que	Mar 85	111
RCDP/PDCE-64	Etude de faisibilité des petites éoliennes aux fins de chauffage domestique aux Iles de la Madeleine (Qué)	Mar 85	137
RCDP/PDCE-65	Etude Energétique de Weymontachie et Obedjiwan	Mar 85	333
RCDP/PDCE-66	Biomass Study, Cartwright and Black Tickle, Labrador	Mar 85	211
RCDP/PDCE-67	Mini-hydro Development, L'Anse au Clair, Labrador, Feasibility Study	Mar 85	115
RCDP-PDCE-68	Assessment of Wind Energy Potential, St. Anthony, Nfld.	Mar 85	149
RCDP/PDCE-69	Wind Energy Conservation Potential of Remote Communities on the Labrador Coast	Mar 85	141
RCDP/PDCE-70	The Potential for Energy Conservation and Fuelwood Substitution in Remote Communities in Nfld. and Labrador	Mar 85	217
RCDP/PDCE-71	Kativik Energy Efficient Study, An Energy Study and Training Program in Kuujjuak and Kangirsuk, Que.	Mar 85	327
RCDP/PDCE-72	Waste Oil Fired Heating System for Municipal Water, Hay River, N.W.T.; A Feasibility Study	Mar 85	255
RCDP/PDCE-73	A Fuelwood Study for Mackenzie Region Communities of the N.W.T.	Mar 85	169
RCDP/PDCE-74	Assessment of Wood Heating Opportunities, Fort Smith, N.W.T.	Apr 85	159
RCDP/PDCE-75	Residential Energy Audit and Retrofit Study, Island Lake Tribal Council communities, Manitoba	Apr 85	319
RCDP/PDCE-76	Small Hydroelectric Development Study, N.W.T., A Feasibility Study	Jun 85	41
RCDP/PDCE-76-A	Summary Report - Small Hydroelectric Development Study, N.W.T.	Jun 85	47
RCDP/PDCE-77	The Feasibility of Electricity Production Using Wood as an Energy Source in Trout Lake and Garden Creek, Alta.	Jul 85	189
RCDP/PDCE-78	Energy Conservation and Off-Oil Study for Institutional Buildings in Saskatchewan's Remote Communities	Nov 85	317
RCDP/PDCE-79	Evaluation of High Temperature Water Heat Distribution System and Waste Heat Recovery at Inuvik, N.W.T.	Oct 85	265
RCDP/PDCE-80	Diesel-Electric Residual Heat Recovery in the Northwest Territories, A Feasibility Study	Oct 85	269
	ENEROPTIONS CASE STUDIES		353

NEWFOUNDLAND

	Name	Pop'n	MapNo
Labrador	Black Tickle	194	28
	Cartwright	658	7
	Charlottetown	250	21
	Davis Inlet	240	23
	Hopedale	425	14
	L'Anse au Loup	589	8
	-Capstan Island	77	8.01
	-English Point		8.02
	-Forteau	520	8.03
	-Fox Cove	247	8.04
	-L'Anse Amour		8.05
	-L'Anse au Clair	267	8.06
	-L'Anse au Diable		8.07
	-Pinware	201	8.08
	-Red Bay	316	8.09
	-West St. Modeste	273	8.1
	Makkovik	347	17
	Mary's Harbour	408	15
	-Lodge Bay	124	15.1
	Mud Lake	72	39
	Nain	938	6
	Paradise River	92	35
	Port Hope Simpson	581	9
	Postville	223	26
	Rigolet	271	20
	St. Lewis	290	18
	William's Harbour	78	38
Northern Newfoundland	Croque	147	30
	Harbour Deep	278	19
	Main Brook	514	11
	Roddickton	1142	4
	-Bide Arm	339	4.1
	-Conche	464	4.2
	-Englee	998	4.3
	Saint Anthony	3107	1
	-Goat Harbour	211	1.01
	-Cape Onion - Ship Cove	279	1.02
	-Cook's Harbour	388	1.03
	-Goose Cove East	368	1.04
	-Great Brehat	120	1.05
	-Hay Cove et al	424	1.06
	-Raleigh	373	1.07
	-St. Anthony Bight	214	1.08
	-St. Carrol's	92	1.09
	-St. Lunaire - Grandois	1010	1.1
	-Wild Bight	54	1.11
	St. Julian's - Grandois	135	31
Central Newfoundland	Change Islands	580	10
	Fogo	1105	5
	-Deep Bay	152	5.1
	-Island Harbour	281	5.2
	-Joe Batt's Arm et al	1155	5.3
	-Seldom	560	5.4
	-Stag Harbour	310	5.5
	-Tilting	427	5.6
	Little Bay Islands	407	16
	St. Brendan's	468	12
	-Dock Cove	38	12.1
	-Hayward's Cove	58	12.2
	-Shalloway Cove	155	12.3
	Westport	467	13
	-Purbeck's Cove	61	13.1
Southern Newfoundland	Burgeo	2504	2
	Francois	219	27
	Grand Bruit	80	37
	Grey River	234	24
	La Poile	186	29
	McCallum	243	22
	Monkstown	112	33
	Petites	108	34
	Petit Forte	90	36
	Ramea	1386	3
	Rencontre East	230	25
	South East Bight	115	32

Note: Decimals are used where several communities are located close together.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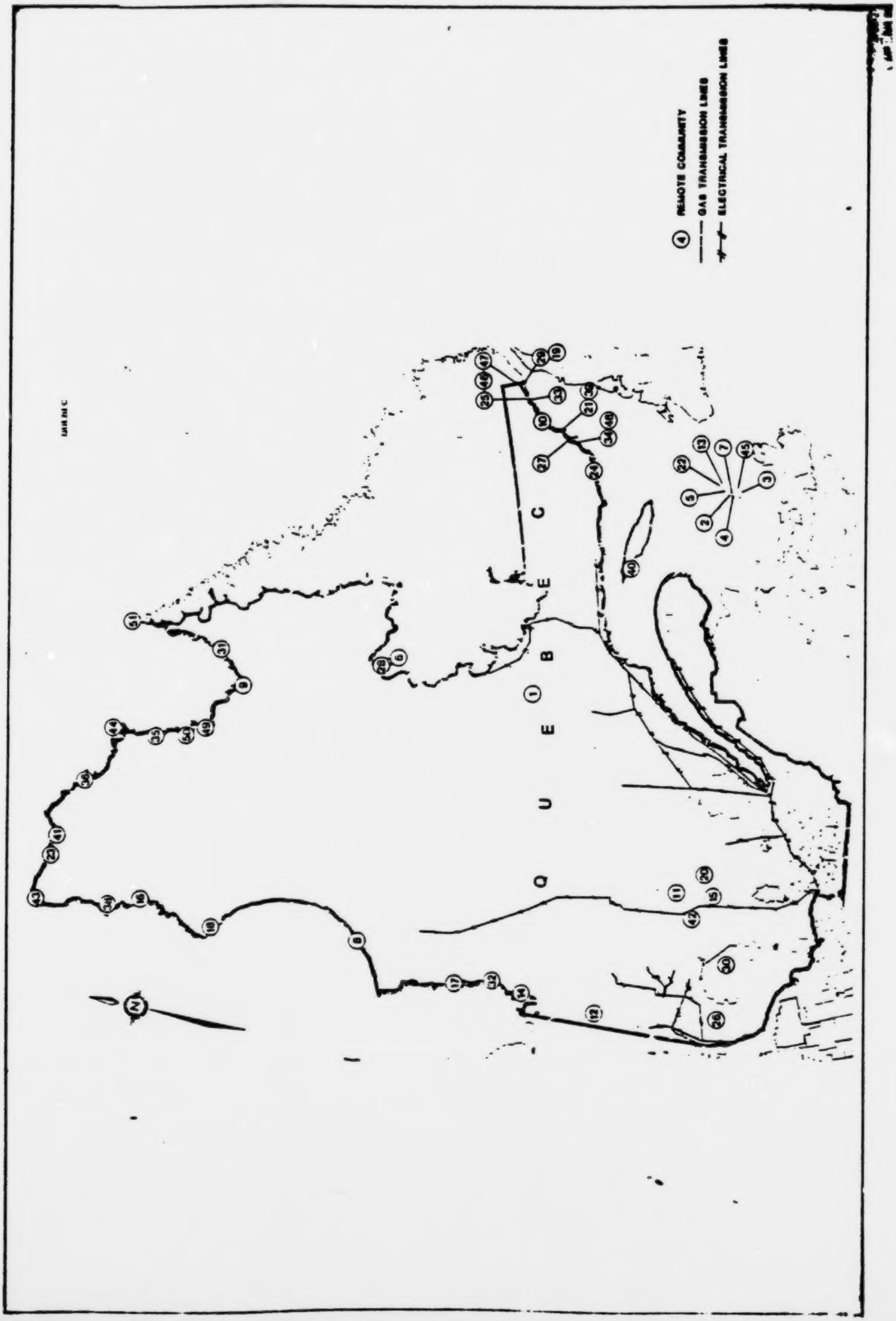
QUEBEC

	Name	Pop'n	MapNo
Nouveau Quebec	Akulivik (Cape Smith)	241	38
	Asbestos Hill	200	41
	Aupaluk	102	50
	Inukjuak (Port Harrison)	650	18
	Ivujivik (C. Wolstenholme)	184	43
	Kangiksuk (Payne Bay)	279	35
	Kangiqsualujjuaq(George R)	333	31
	Kangiqsujuaq (Maricourt)	279	36
	Killinik	-0-	51
	Kuujjuak (Fort Chimo)	1068	9
	Kuujjuaraapik (P. Baleine)	1133	8
	Povungnituk	752	16
	Quaqtaq	163	44
	Salluit	518	23
	Tasiujak (Leaf Bay)	106	49
	Uumaruk	-0-	52
Central Quebec	Belleterre	470	26
	Clova	200	42
	Eastmain	329	32
	Fort Rupert	946	14
	Gagnon	3500	1
	Kawawchikamach	397	28
	Lac Rapide	337	30
	Obedjiwan	1103	11
	Parent	800	15
	Schefferville	1928	6
	Selbaie	1000	12
	Wemindji	674	17
	Weymontachie	613	20
Lower North Shore	Anticosti	224	40
	La Romaine	511	24
	La Tabatiere	526	21
	-Aylmer Sound	110	48
	-Chevery	228	39
	-Harrington Harbour	311	34
	-Mutton Bay	260	37
	-Tete a la Baleine	446	27
	Lourdes de Blanc Sablon	625	19
	-Blanc Sablon	361	29
	-Bradore Bay	123	47
	-Middle Bay	143	46
	-Old Fort Bay	312	33
	-St. Paul's River	495	25
	St. Augustin	1059	10
Magdalen Islands	Cap-aux-Meules	1350	7
	-Etang du Nord	2702	4
	-Fatima	3109	2
	-Grand Entree	979	13
	-Grosse Ile	523	22
	-Havre aux Maison	2500	5
	-Havre Aubert	2974	3
	Iles d'Entree	154	45


QUEBEC
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4 REMOTE COMMUNITY
GAS TRANSMISSION LINES
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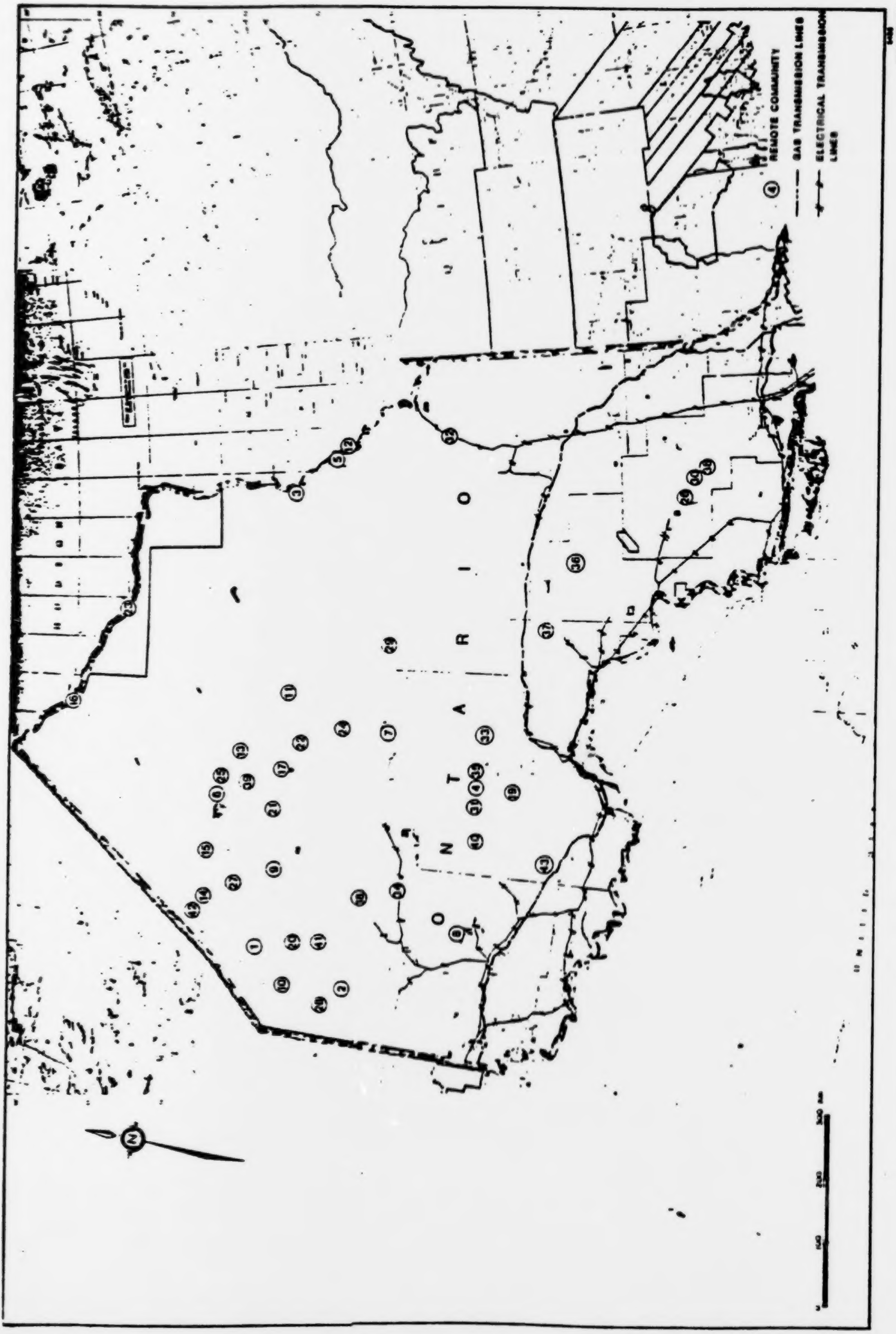
ONTARIO

	Name	Pop'n	MapNo
Native Coastal	Attawapiskat	828	3
	Fort Albany	447	12
	Fort Severn	318	16
	Kashechewan	798	5
	Winisk	232	23
Rail Community	Allan Water	50	40
	Armstrong	800	4
	Auden	85	33
	Biscotasing	135	38
	Collins	100	31
	Ferland	81	35
	Graham	90	43
	Hillsport	68	37
	Moose River Crossing	90	32
	Oba	75	36
	Ramsey	127	30
	Sultan	179	26
Native Interior	Angling Lake(Wapekaka)	206	25
	Bearskin Lake	336	15
	Big Trout Lake	750	6
	Cat Lake	315	18
	Deer Lake	481	10
	Fort Hope	705	7
	Gull Bay	286	19
	Kasabonika	444	13
	Kingfisher	253	21
	Lac Seul	537	8
	Lansdowne House	209	24
	Long Dog Lake	35	39
	MacDowell	26	41
	Muskrat Dam	173	27
	North Spirit Lake	282	20
	Ogoki/Marten Falls	150	29
	Pikangikum	946	2
	Ponask	31	42
	Poplar Hill	171	28
	Sachigo	339	14
	Sandy Lake	1344	1
	Slate Falls/Fry Lake	82	34
	Summer Beaver	250	22
	Weagamow(Caribou Lake)	531	9
	Webequie	455	11
	Wunnummin Lake	318	17


ONTARIO
REMOTE COMMUNITY
GAS TRANSMISSION LINES
ELECTRICAL TRANSMISSION LINES
N

ALBERTA

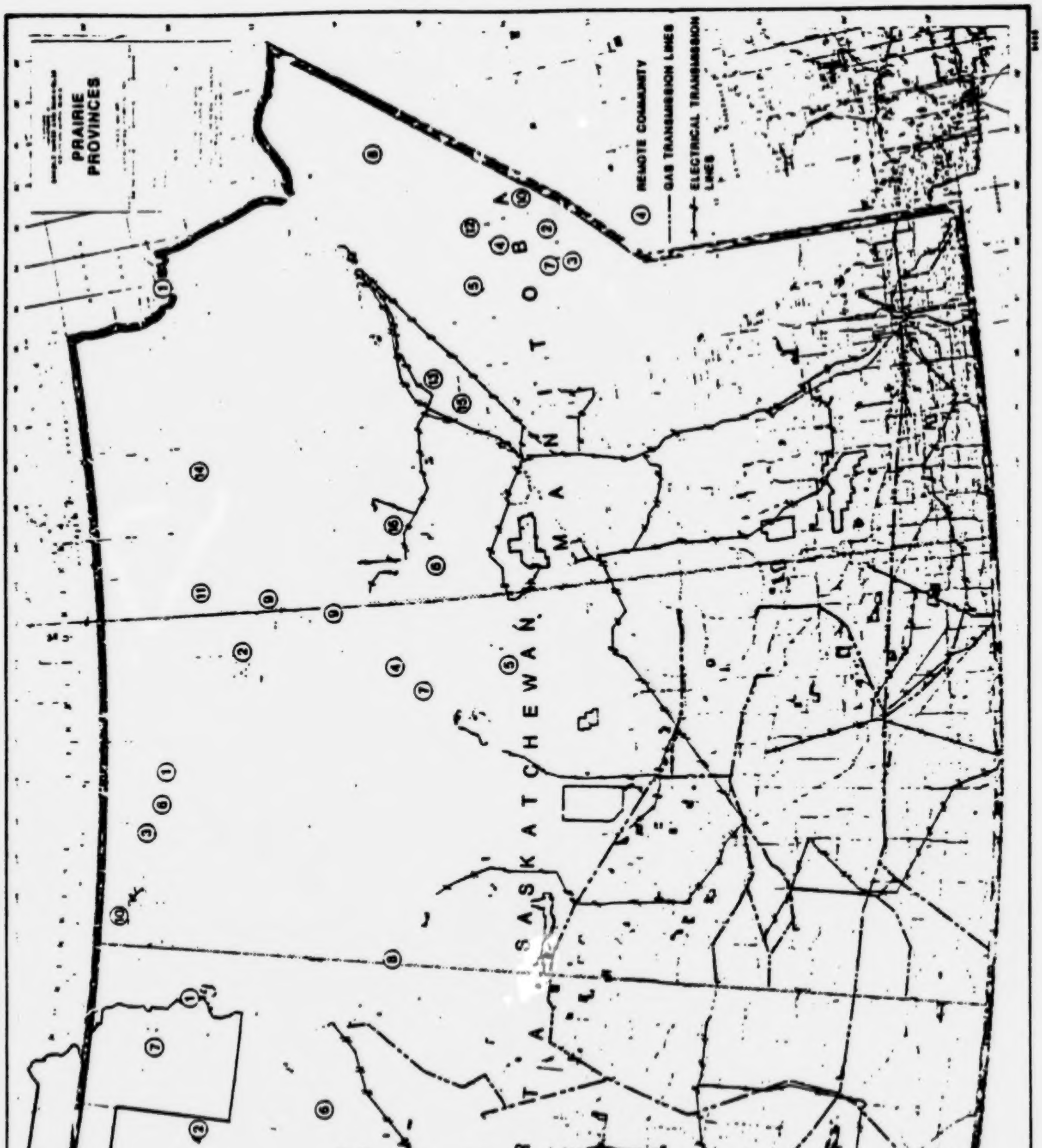
Name	Pop'n	MapNo
Fort Chipewyan	1600	1
Jean d'Or Prairie	650	3
Fox Lake	750	2
Trout Lake AB	203	5
Peerless Lake	204	4
Chipewyan Lake	150	6
Peace Point	65	7
Garden Creek	150	8

SASKATCHEWAN

Name	Pop'n	MapNo
Black Lake	818	1
Brabant	129	7
Camsell Portage	61	10
Deschambault	517	5
Fond du Lac	724	3
Garson Lake	84	8
Kinoosao	31	9
Southend	528	4
Stony Rapids	275	6
Wollaston	543	2

MANITOBA

Name	Pop'n	MapNo
Brochet	640	9
Garden Hill	1900	2
God's Lake Narrows	1250	4
God's River	250	12
Granville Lake	140	16
Lac Brochet	380	11
Oxford House	1250	5
Pikwitonei	203	13
Pukatawagan	1100	6
Red Sucker Lake	425	10
St. Theresa Point	1450	3
Shamattawa	690	8
Tadoule Lake	215	14
Thicket Portage	200	15
Waasagomach	730	7
Churchill	1600	1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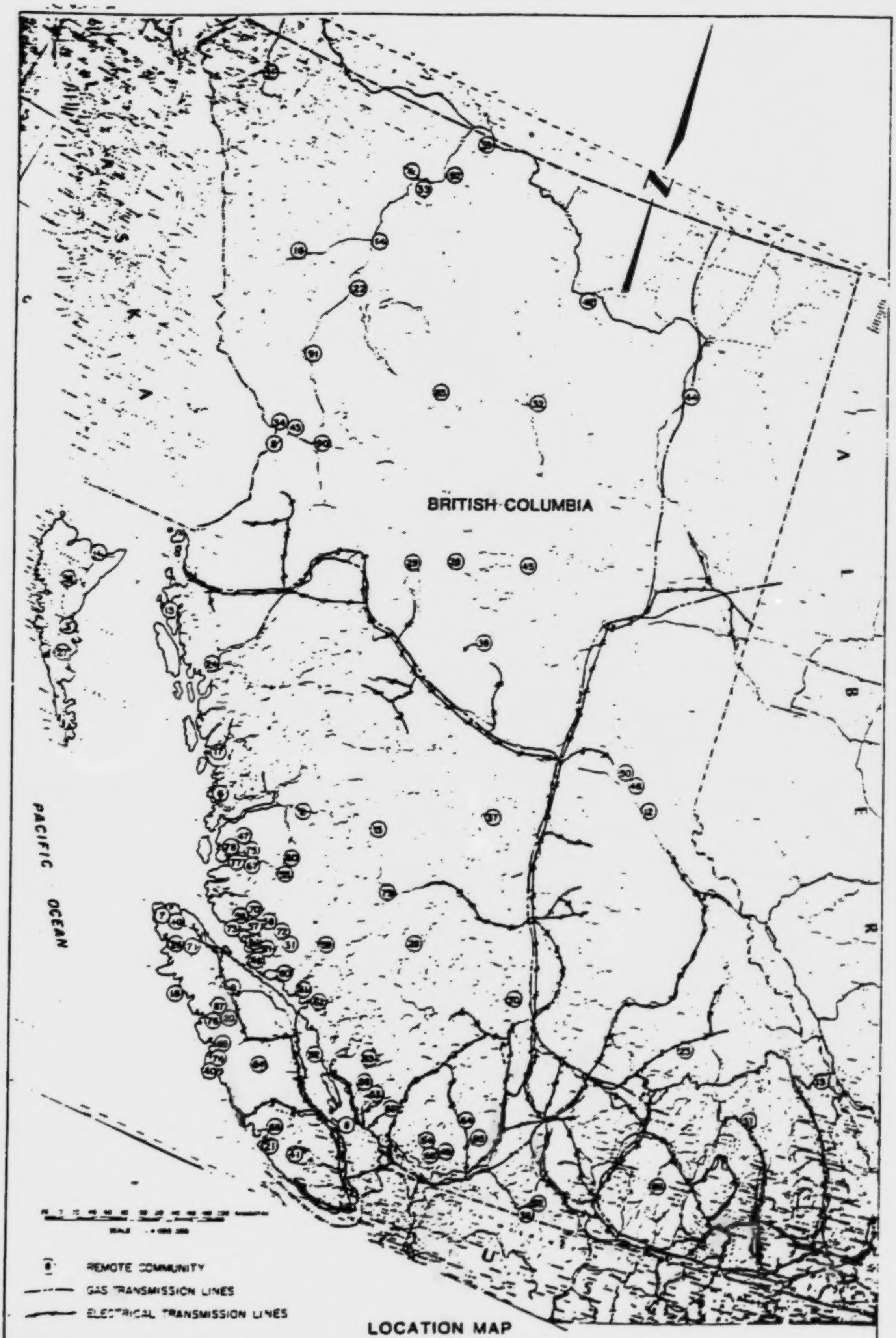
REMOTE COMMUNITY
GAS TRANSMISSION LINES
ELECTRICAL TRANSMISSION LINES
ALBERTA
SASKATCHEWAN
MANITOBA
N

BRITISH COLUMBIA

Name	Pop'n	MapNo
ACTEON SOUND	45	56
ANAHIM LAKE	372	15
ATLIN	475	11
BAKER MINE CAMP	30	83
BAMFIELD	250	21
BARCLAY DIV.(KILDONAN)	45	66
BARR CREEK	25	87
BELLA BELLA	1414	6
BELLA COOLA	3047	2
BIG BAR/JESMOND CREEK AREA	133	30
BOB QUINN LAKE	17	91
BOULDER BAY	45	68
CASSIAR	1850	4
CHRISTIAN VALLEY	23	86
CLEAGH CREEK	45	71
DEASE LAKE	425	14
DOME CREEK / CRESCENT SPUR	475	12
DRURY INLET	45	73
EARLS CREEK	25	88
EASTGATE	50	52
ERICKSON GOLD MINE VILLAGE	130	33
FIELD	270	19
FORT BABINE IR #6	170	29
FORT WARE	145	32
GERMANSEN LANDING	77	45
GILFORD ISLAND	67	48
GOOD HOPE LAKE - HIGHWAYS	12	92
GREENWOOD CAMP	64	74
HARTLEY BAY	214	24
HESQUIAHT	90	40
HOLBERG	476	10
HOLBERG DND	650	7
HORNET	30	85
ISKUT/EDDONTENAJON	250	22
JUSKATLA	100	38
KILBELLA BAY	61	75
KINGCOME INLET	134	31
KINGCOME INLET (WHONNOCK)	45	72
KITKATLA	463	13
KLEMTU	313	17
KNIGHT INLET	45	59
KYUQUOT	300	18
LASQUETI ISLAND	457	8
LONGWORTH	53	50
LOWER POST	123	35
MACHMELL	45	55
MAHATTA RIVER	200	26
MANNING PROVINCIAL PARK	121	36
MASSET	3175	1
MCNAB CAMP	24	89
MEZIADIN LAKE - HIGHWAYS	17	90
MOOYA BAY (NOOTKA)	45	65

Name	Pop'n	MapNo
MOSES INLET	70	47
NARROWS INLET LOGGING DIV.	45	53
NAZKO INDIAN BAND	110	37
NEMAIAH VALLEY INDIAN BAND	175	28
NICKNAGUEET	40	77
NITINAHT	81	41
NUCHATLAHT	40	76
OWIKENO	45	67
PENNY	74	46
PHILLIPS ARM	45	61
PITT LAKE	45	54
PORT DOUGLAS (HARRISON)	45	64
PORTAGE (NANCUT)	95	39
PROPHET RIVER	79	44
QUATAM RIVER	45	42
SANDSPIT	3000	3
SAVARY ISLAND	31	82
SCOTT COVE	45	69
SCOTTY GOLD	80	43
SECHELL CREEK	45	57
SEWELL INLET	180	27
SEYMOUR ARM	140	[illegible]
SEYMOUR INLET	45	[illegible]
SHEEMAHANT	47	80
SHOTBOLT	40	78
SIMOON SOUND	33	81
STAVE LAKE	55	45
STEWART	1456	5
TAKLA	208	25
TATLA LAKE	37	73
TELEGRAPH CREEK	350	16
TIDE LAKE	125	34
TIMFOR	45	57
TOAD RIVER AREA	80	42
TOM BROWN LAKE	45	60
TROUT LAKE BC	50	51
VERNON	251	[illegible]
WAKEMAN SOUND	45	58
WESTERN MINES (MYRA FALLS)	30	84
WOSS	543	9


BRITISH COLUMBIA
PACIFIC OCEAN
ALASKA
ALBERTA
U S
N
REMOTE COMMUNITY
GAS TRANSMISSION LINES
ELECTRICAL TRANSMISSION LINES

LOCATION MAP

YUKON

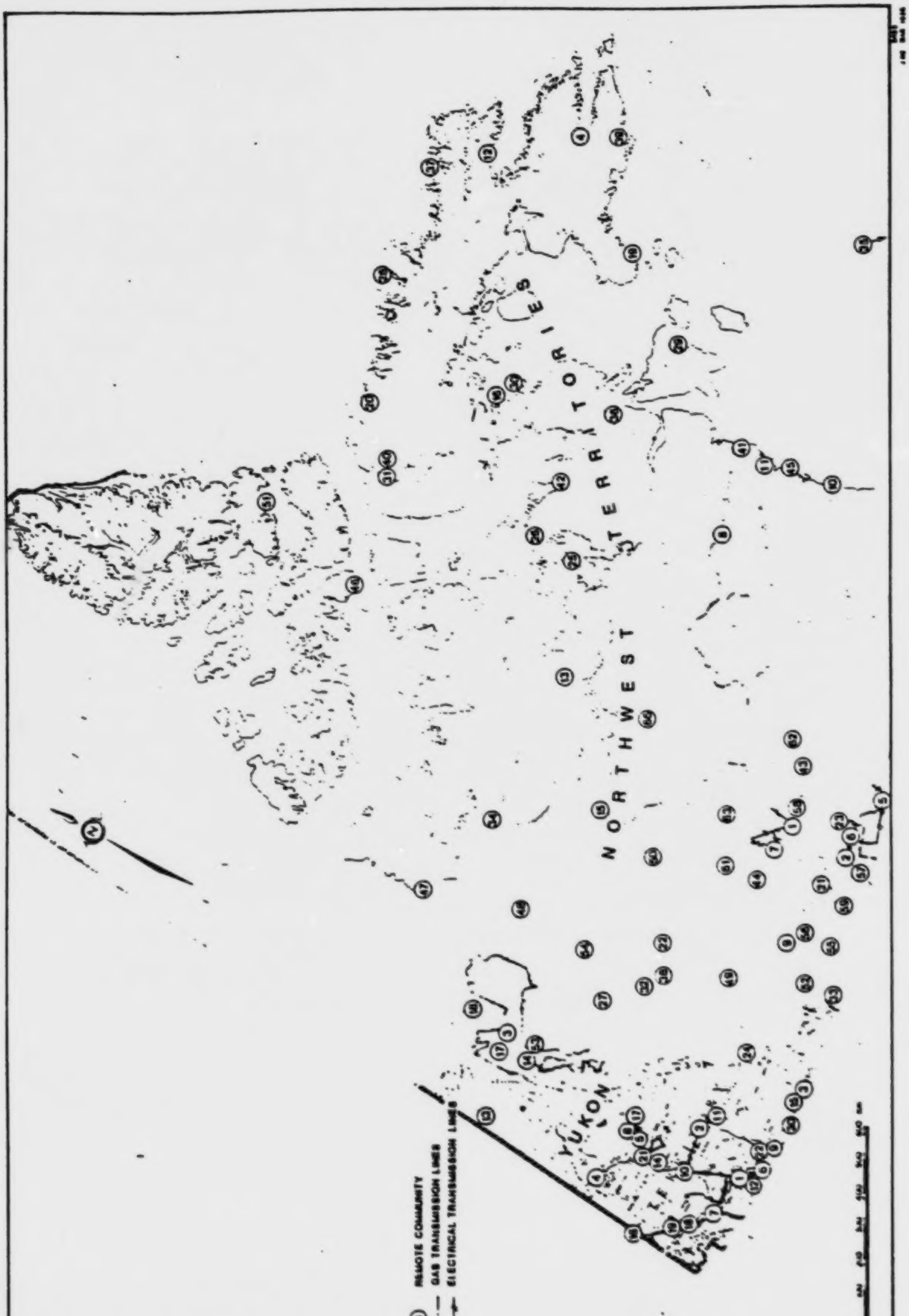
	Name	Pop'n	MapNo
Urban	Dawson City	900	4
	Watson Lake	1140	3
	Whitehorse	15000	1
Mining	Faro	1700	2
	Mayo	500	5
	Elsa	400	8
	Keno	90	17
Other	Beaver Creek	90	16
	Burwash Landing	70	19
	Destruction Bay	80	18
	Carcross	270	12
	Carmacks	340	10
	Haines Junction	460	7
	Johnsons Crossing	10	22
	Old Crow	240	13
	Pelly Crossing	180	14
	Ross River	325	11
	Stewart Crossing	20	21
	Swift River	35	20
	Tagish & Marsh Lake	480	6
	Teslin	368	9
	Upper Liard	130	15

NORTHWEST TERRITORIES

	Name	Pop'n	MapNo
Baffin	Arctic Bay	377	31
	Broughton Island	314	37
	Cape Dorset	725	19
	Clyde River	443	28
	Frobisher Bay	2454	4
	Grise Fiord	95	51
	Hall Beach	396	30
	Igloolik	766	16
	Lake Harbour	300	39
	Nanisivik	291	40
	Pangnirtung	909	12
	Pond Inlet	652	20
	Resolute	177	46
	Sanikiluaq	334	35
Keewatin	Baker Lake	1017	8
	Chesterfield Inlet	281	41
	Coral Harbour	414	29
	Eskimo Point	980	10

NORTHWEST TERRITORIES (Cont.)

	Name	Pop'n	MapNo
Keewatin	Rankin Inlet	956	11
	Repulse Bay	328	36
	Whale Cove	203	45
Kitikmeot	Bathurst Inlet	30	66
	Cambridge Bay	864	13
	Coppermine	756	15
	Gjoa Haven	493	25
	Holman	336	34
	Pelly Bay	281	42
	Spence Bay	470	26
Inuvik	Aklavik	756	17
	Arctic Red River	79	53
	Colville Lake	73	54
	Fort Franklin	554	22
	Fort Good Hope	446	27
	Fort McPherson	751	14
	Fort Norman	312	38
	Inuvik	2893	3
	Norman Wells	361	32
	Paulatuk	166	48
	Sachs Harbour	170	47
	Tuktoyaktuk	747	18
Fort Smith	Detah	143	55
	Enterprise	40	57
	Fort Liard	344	33
	Fort Providence	571	21
	Fort Resolution	[illegible]	[illegible]
	Fort Simpson	1001	9
	Fort Smith	2234	5
	Hay River	3245	2
	Jean Marie River	49	56
	Kakisa	36	59
	Lac la Martre	231	44
	Nahanni Butte	92	52
	Paradise Gardens	-0-	60
	Pine Point	1719	6
	Port Radium	140	50
	Rae Lakes	200	61
	Rae Edzo	1367	7
	Snare Lakes	[illegible]	63
	Snowdrift	254	43
	Trout Lake	61	[illegible]
	Tungsten	506	[illegible]
	Wrigley	163	[illegible]
	Yellowknife	9913	1


REMOTE COMMUNITY
GAS TRANSMISSION LINES
ELECTRICAL TRANSMISSION LINES
YUKON
NORTHWEST TERRITORIES
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Continued

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SECTION 1

OVERVIEWS

ENERGY OVERVIEW OF CANADA'S REMOTE COMMUNITIES

EXECUTIVE SUMMARY

Canada's remote communities are distinct from Canada's urban communities and diverse amongst themselves. Besides the obvious differences of geography and climate, the communities include lifestyles ranging from primitive to modern and economies ranging from traditional subsistence to industrial. The consequent use of energy is influenced by the climate, lifestyle and economy of the community while its cost is a function of geography and the efficiency by which the energy is transported and sold. This Energy Overview of Canada's Remote Communities was prepared to assist Energy Mines and Resources Canada to catalogue and analyse the remote community energy data available from existing sources and indicate the potential for reducing energy consumption and in particular reduce the need for petroleum products.

The incentive in saving energy is an economic one from both local and national perspectives. The high degree days of heating required in many remote communities coupled with the high transport cost of energy combine to give costs of energy far in excess of the rest of the country. Costs are potentially so high that severe economic constraints could result because energy expenses (where the consumer pays the cost of energy) can become the largest household expense in a low income family. Consumer energy costs are relieved in many communities, because of local energy availability (hydro and wood), and subsidies. The consumers themselves adapt to high energy costs by space heating smaller homes to a lower comfort level and by curtailing, either voluntarily or by regulation, the use of electricity. The Overview provides listings and summaries of several key energy categories to assist with the understanding of community energy uses and costs.

Methods to assist with the goals of energy conservation and reduction of petroleum uses are available to many communities. Conservation can be achieved through upgraded building insulation, waste heat recovery and energy management. Fuel substitution can occur with the use of small hydro, wood, wind and solar as the principal locally available energy sources. Connections could be made to central electricity and natural gas systems in some instances and there are a number of developing technologies. Many remote communities already make use of some of these options, but there could be more widespread use and a consequent reduction in energy needs. The study estimates that the use of energy could be reduced by 25% to 26.7 PJ/year and the use of oil reduced by 38% to 13.2 PJ/year if the communities improved their energy related infrastructure and developed the feasible local sources of energy. The resulting cost of oil saved would be $80M/year based on the average cost and savings potential. These figures are felt to be conservative, because many of the energy conservation possibilities were only taken to cover part of the community. Improved data on community infrastructure can be used with the database package to update estimates in future years.

The rate of conversion to improved energy systems in remote communities has been relatively slow, and a number of technical, economic and institutional barriers have been identified which are hindering the process. Technical barriers include the requirement for proof of technical feasibility and the

development of a successful maintenance program, including management and technical skills within the community. Economic barriers include the requirement for proof of economic feasibility and a requirement to finance the high capital costs of many conservation and alternative energy systems. An understanding of the annual costs of improvements to the energy system relative to existing energy costs must be developed. The institutional barriers include the policies of the many agencies, both government and commercial, which are involved in the supply and use of energy in remote communities. These policies, and the physical infrastructure which has been built because of them, serve to limit some of the technical options available, and introduce economic constraints imposed by the agencies' views of the energy scene affecting their own interests. Reference to the community energy tables and charts indicates that in communities which have a low level of economic activity, government and commercial energy use often exceeds residential use, with the average ratio of residential energy to total community energy use for all remote communities being about 30%. Therefore overcoming the related barriers will lead to a significant improvement in community energy use.

The Energy Overview of Canada's Remote Communities has catalogued all of the available community energy information in a consistent format. Through the use of a database management program, the information has been summarized in one page reports, while key numerical data has been tabulated for the various regions. A spreadsheet program has been used to provide more detailed numerical analysis and graphs of key energy categories provide a rapid visual analysis of community energy in each region. The database is readily changed when information is available. Further improvements in remote community energy use will be possible once more information about community infrastructure and resources is known, once technical developments are proven and once economic evaluations in all situations are performed consistently. The result will be an understanding of the energy options available to communities and the resulting benefits which will accrue on the local, regional and national levels.

1.0 EXECUTIVE SUMMARY

The general purpose of this desk study overview is to ascertain the potential for Yukon communities to reduce their dependence on oil. Specific objectives are to:

- outline the Yukon energy environment, including barriers to oil displacement;
- document current energy consumption patterns for individual communities;
- provide brief community profiles from an energy perspective;
- consider community off oil options based on practical technology;
- recommend measures for reducing oil consumption;
- identify gaps in the energy picture requiring further study.

As shown in Table 1-1 all communities in the Yukon are highly dependent on refined petroleum products for space heating requirements. Half of them also rely on diesel fuel for electrical generation needs. As a result, close to 75 million liters of fuel oil were consumed in the Yukon in 1982 for these purposes.

Residential space heating represents the most significant end-use for oil. There is evidence of an increasing trend toward using wood as either a supplement or substitute to oil heating. The potential for further wood use is significant. Wood burning has made only minor penetration into the government, commercial and industrial sectors however.

While the oil consumed for electrical generation in the Yukon is less than 10 percent of that used for space heating, it presents a particularly difficult problem in that the conversion inefficiencies inherent in diesel generation make the resulting energy quite expensive.

About one-quarter of the total energy demand of Yukon communities is supplied by hydro-electric generation. Eight communities, including Whitehorse, the largest, are supplied electricity from an interconnected grid stretching from Haines Junction in the southwest to Ross River in the northeast. An isolated hydro-electric distribution system also serves the communities of Mayo, Elsa and Keno.

Invariably, the most cost-effective and practical means of reducing oil consumption in remote communities in the Yukon is through conservation. Based on limited data on air-

TABLE 1-1

YUKON COMMUNITIES ENERGY USE SUMMARY

COMMUNITY	POPN	GJ INPUT PERCAPITA	GJ USED PERCAPITA	TOTAL MWH	TOTAL SPHT GJ	WOOD GJ	OIL GJ	ELEC FUEL GJ
STEWART CROSSING	20	467	235	380	3360	0	3360	6000
JOHNSONS CROSSING	10	353	185	33	1730	1430.	300	1800
BEAVER CREEK	90	339	234	1000	17500	800	16700	13000
DAWSON CITY	900	266	191	7000	147000	16700	130300	92000
SWIFT RIVER	35	264	154	240	4500		4500	4700
DESTRUCTION BAY	80	247	167	700	10800	1600	9200	9000
WATSON LAKE	1140	209	144	8900	132600	21000	111600	105600
BURWASH LANDING	70	190	140	400	8900	4800	4000	5100
UPPER LIARD	130	157	138	300	17000	15100	1900	3600
TESLIN	368	155	112	1770	35000	15100	19900	22000
ROSS RIVER	325	137	137	1450	39400	21000	18400	
WHITEHORSE	15000	135	135	140000	1527000	91000	1436000	
HAINES JUNCTON	460	134	134	3200	50000	13600	36400	
OLD CROW	240	127	96	700	20800	14700	6100	10000
MAYO	500	127	127	4000	49300	9200	40100	
CARMACKS	340	122	122	1900	34400	15200	19200	
PELLY CROSSING	180	120	77	680	11600	7200	4400	10300
CARCROSS	270	111	111	1000	26300	13900	12400	
KENO	90	105	105	200	8500	4250	4250	
FARO	1700	102	102	14800	120000		120000	
ELSA	400	93	93	2900	26900		26900	
TAGISH- MARSH LK	480	74	74	600	33500	25500	8000	
TOTAL	22828			192153	2325990	292080	2033910	283100
AVERAGE		183	137					
INDUSTRIAL FARO				125000	coal:	150000	22000	
INDUSTRIAL ELSA				26500			113000	
TOTAL YUKON	22828			343653	2325990		2168910	293100

TOTAL OIL: 2452010

TOTAL FUEL 2894090

tightness and insulation levels in the Yukon, it is certain that most buildings could effect direct reductions in oil consumption for space heating by retrofitting additional insulation and air-vapour barriers. Commercial and government buildings, which tend to be heated solely by oil, represent the best opportunities for oil savings.

For communities dependent upon diesel electric generation, waste heat recovery offers another proven and effective means for conservation. It is probably not feasible to provide extensive hot water distribution systems in most communities, but large buildings or closely clustered sets of buildings could certainly benefit.

Hydro and wood are the most plentiful renewable energy resources in the Yukon. Both are used now and consumption could be increased to displace more oil. Many communities in the Yukon have good access to large areas of fire-killed forest which serve as excellent sources of dry, seasoned firewood. Wood is readily applicable for space heating purposes while electrical generation fueled by wood is more problematical. (Wood is obviously less convenient than oil, but increasing oil prices are overcoming this objection.) Many communities would benefit from the development of a fully integrated wood supply system to remove some of the barriers inherent in its use. Supply and handling difficulties are also critical when considering large scale applications of wood as an energy source.

The combination of good supply and sufficiently large load demand could indicate the suitability of using wood for electric generation in communities such as Watson Lake or Teslin. At the present time, however, conventional steam powered generation is the only proven technology, and this requires very large quantities of wood. Detailed investigation of the economics of such a system would be required before a demonstration project could be initiated. Almost certainly, heat recovery and district heating would have to be incorporated in the system.

Small hydro offers an opportunity to virtually eliminate all oil consumption in remote communities for other than transportation uses. Several communities, that are presently served by diesel electricity, are identified in this study as having sites nearby where hydro could be developed. Although hydro offers very low operating costs, the capital costs can be quite high. In addition, the social and environmental constraints to specific potential hydro sites can be significant. Detailed site investigations are required to determine these factors. Nevertheless, using some "rule of thumb" estimates, several opportunities for small hydro appear promising.

Grid connected communities could also reduce their oil dependence to very minor levels by converting from oil heating to electric heating. Already, the price differential between the two is diminishing and future oil increases will clearly tip the balance in favour of electricity. The key question becomes one of capacity on the system. At the present time, there is a surplus of close to 20 MW, enough to satisfy the total energy needs of between one-third and one-half of the households in the Yukon. However, this surplus largely results from the shut down of the lead-zinc mining works at Faro. Whether Cyprus Anvil will require this capacity in the future creates a serious policy dilemma for the time being.

Other technologies which show some promise in at least one community in the Yukon include:

- Biogas Production from Organic Waste;
- Wind Power/Pumped Storage;
- Heat Pumps;
- Propane.

SUMMARY

The Remote Community Demonstration Program is designed to help isolated communities improve their energy situation by finding viable means of reducing the use of petroleum based fuels for space heating and power generation. The Energy Overview Study for Remote Communities in British Columbia is an early stage of the program intended to catalogue and profile the energy use patterns of the communities to assist Energy, Mines and Resources Canada in decisions regarding the allocation of funding for feasibility studies and subsequent demonstration projects.

Remote communities in British Columbia exist for a variety of reasons and for the purpose of this program they are broadly defined as having at least 10 principal dwelling units, at least 5 years of planned life remaining and no firm commitment for connection to the electrical grid or the natural gas network.

The Remote Community Demonstration Program is operating in every region of Canada, but it is especially relevant to British Columbia where about 90 of the 300 to 400 remote communities are located.

A large proportion of the remote communities (45 percent) are associated exclusively with resource development, such as forestry and mining camps. Although described as camps, these communities usually have more than 10 years of planned life remaining and provide a high level of employment for most of the year. The second largest group of communities, accounting for 30 percent of the total, exists for historical reasons, as people have traditionally lived at the location. Six of these communities have a strong resource base while the others have a low level of employment. The remaining remote communities (each accounting for 5 - 10 percent of the total) are categorized as: catering to tourism including recreational properties; agricultural centres including farming and ranching; and settlements which have developed on transportation routes.

ENERGY OVERVIEW STUDY OF ALBERTA'S REMOTE COMMUNITIES

EXECUTIVE SUMMARY

A remote Community Demonstration Program was introduced in 1982, as part of the Federal Government's Off-Oil objectives. Part I of the Program is designed to assess the scope for alternative energy supplies and conservation by developing a comprehensive data base and screening approaches to reduced oil use. Later Phases will be concerned with more-detailed study of potentially-attractive options and implementation of demonstration projects.

This report analyzes existing and probable future energy supply and demand scenarios for eight remote communities in Alberta. These communities all depend on diesel fuel for electricity generation and on heating oil or propane for space heating in institutional and commercial buildings. Wood, rather than heating oil or propane, is the main source of energy for residential space heating and cooking.

The report describes the communities and their energy use and includes projections of probable future use. Based on these projections and the availability of energy sources, preliminary assessments are made of alternatives to existing energy supplies. The opportunities for reducing oil consumption through conservation are also reviewed.

The existing situation is described in Chapters 1 and 2. Chapter 3 contains projections of fuel use (excluding fuel used for transport) in all eight isolated communities in Alberta to the year 1990. The projected total demand for oil-based fuels is estimated at 4,100 m^3 of diesel oil and 2,100 m^3 of heating oil.

In Chapter 4, alternative sources of energy which could be considered as potential sources of replacement for petroleum-based fuels in these communities are discussed. This is followed, in Chapter 5, by a preliminary economic evaluation of some of the, apparently, more-attractive substitution possibilities. There could be scope for connection to either the electric power grid or the gas distribution grid in the cases of Jean d'Or Prairie and Fox Lake and there is also a potential for development of a small hydro plant at Vermilion Falls between these communities.

Chipewyan Lake could obtain gas from a nearby gas field. Waste heat recovery from diesel plants could be an attractive option but is currently not economic in most communities due to the distances between major users of energy for space heating and the diesel plants. This option should be considered when new plants are built. Power plant relocation could be consideredin some existing communities. Current relative prices of oil, propane and wood make direct substitution of wood for oil and propane* unattractive in Alberta for the purpose of space heating of large buildings. The same applies to wood-gasification installations although the demonstration project at Fort Providence, Northwest Territories, should be monitored to determine whether such projects are desirable for use in Alberta. The manufacture of charcoal from wood cut for highways, pipelines, seismic lines and agricultural clearing has been found to be potentially attractive. This wood is currently burned as waste.

Energy conservation is discussed in Chapter 6. Significant opportunities exist in schools, other official buildings and in commercial establishments. Barriers to energy conservation and fuel substitution are discussed in Chapter 7. Several of the more important barriers could be removed by attention to appropriate building standards, institutional relationships, financial incentives and dissemination of information regarding current technologies and programs.

Conclusions and Findings are presented in Chapter 8. Finally, in Chapter 9, some suggestions are made regarding demonstration projects which could be pursued during the next phase of the Remote Community Demonstration Program in several remote communities in Alberta. Some further work would be necessary to determine whether such projects should be pursued but among those suggested are a small hydro project, waste heat recovery from diesel engines, and a concerted effort on a community level to conserve energy.

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* Propane is not in short supply in Alberta since it is a by-product of natural gas production. The analysis of substituting wood for propane was performed to determine whether the communities studied can become more self-reliant using nearby resources.

REMOTE SASKATCHEWAN COMMUNITY ENERGY OVERVIEW STUDY

Executive summary

The Remote Community Demonstration Program was introduced in 1982 as part of the federal government's oil-off initiative. Part of the program involves assessing the scope for conservation and for alternative energy supplies by developing a comprehensive data base and screening approaches to reduce oil use. Other aspects of the program involve more detailed study of potentially attractive options in remote communities and implementation of demonstration projects.

Basically, the program defines a "remote community" as one that has at least 10 permanent residences, at least five years of planned life remaining and is not now connected to or firmly committed to connection with piped natural gas or provincial electrical grids. When work on this study began, 15 communities in Saskatchewan met the definition. However, Saskatchewan Power Commission has since announced that five will be connected to its grid. Since information on these communities had already been collected, the report includes them (Dillon, Michel Village, Patunak, Pinehouse and St. Georges Hill). It should be noted, however, that only the remaining 10 are eligible under the program (Black Lake, Brabant Lake, Camsell Portage, Deschambault Lake, Fond du Lac, Garson Lake, Kinoosao, Southend, Stony Rapids and Wollaston).

These communities all depend on diesel fuel for electricity generation and on heating oil or propane for space heating in institutional and commercial buildings. Wood, rather than heating oil or propane, is the main source of energy for residential space heating, cooking and water heating.

In the 10 Saskatchewan communities designated as remote, the population of 3,452 used 276,065 GJ of energy in 1982 for all purposes other than transportation. With the high cost of that energy, the report examines a number of potential alternative energy options for each community. Depending on the community, small hydro (under 5MW), wood gasification or grid connection was usually the best choice. The report describes in detail each community and its energy use.

The energy resource base of Northern Saskatchewan is surveyed in general terms. Potential small hydro-electric sites are indicated; forest, peat and wind resources are reviewed; and extension of the electrical grid is discussed. Opportunities for reducing oil consumption through energy conservation are also reviewed.

Appendices explain the following technologies: small scale and micro hydro, wood conversion, wind-electric conversion systems, and synthetic fuels from biomass.

ENERGY PROFILES FOR MANITOBA REMOTE COMMUNITIES

Executive Summary

The Remote Community Demonstration Program was introduced in 1982 as part of the federal government's off-oil initiatives. The program is designed to promote the awareness and adoption of energy conservation practices and alternative-to-oil energy sources in remote communities in Canada.

To help in the operation and future planning of the program, Energy, Mines and Resources Canada commissioned this "energy overview" study to identify and profile remote communities in Manitoba which are eligible under the program, and to identify potential alternative energy sources and energy conservation options open to these communities.

Basically, a "remote community" is defined as one that has at least 10 permanent residences, at least five years of planned life remaining and is not now connected or firmly committed to connection with piped natural gas or main electrical grids.

In Manitoba, 16 communities met this definition. They are Brochet, Garden Hill, God's Lake Narrows, God's River, Granville Lake, Lac Brochet, Oxford House, Pikwitonei, Pukatawagan, Red Sucker Lake, St. Theresa Point, Shamattawa, Tadoule Lake, Thicket Portage, Waasagomach and Churchill. The first 15, with a combined population of about 11,000, have similar demographic, economic and energy-use characteristics. The sixteenth, Churchill, with a population of about 1,600, has a much higher per capita consumption of energy, the result of higher living standard and greater economic activity.

All 16 communities depend on diesel fuel for electricity generation and on heating oil or propane for space heating in institutional and commercial buildings. In communities other than Churchill, wood (rather than heating oil or propane) is the main source of energy for residential space heating, cooking and water heating.

In 1982, Churchill consumed 544,644 GJ of energy. Oil products made up 80% of this total, and propane the remainder. The other 15 communities used 702,520 GJ of energy that year. Oil products, for commercial, institutional and space heating and electricity generation, accounted for 51%. Fuel wood, mainly for residential space heating, made up approximately 49%.

Because the cost of shipping oil and propane products into the communities is so high -- especially for small-volume users and communities accessible only by air -- energy costs are much higher than in the south. Transportation costs add about 20% to the Winnipeg price of bulk fuel in communities on the railroad, about 25% in places served by winter roads, and up to 100% in places where fuel is shipped by air.

The report concludes that four major opportunities exist to reduce energy usage and costs in the 16 communities. They are:

- using fuel wood to replace some 3,500,000 litres of heating oil used annually to heat public institutional and commercial buildings in the 15 similar communities;
- improving design and construction of houses to reduce, by several thousand cords per year, the quantity of fuel wood needed to heat existing and future homes;
- connecting certain communities to the main Manitoba Hydro electrical grid or harnessing small hydro-electrical generating opportunities near communities, to replace much of the 13,800,000 litres of fuel oil used annually to generate electricity; and
- substituting propane for electrical heating -- depending on the outcome of studies and negotiations -- to replace some 3,100,000 litres of fuel oil used annually for heating in Churchill.

The report describes in detail each remote community and its energy use.

The study was done in 1983 by Unies Consulting Engineers Ltd. of Winnipeg for the Remote Community Demonstration Program of Energy, Mines and Resources Canada.

ENERGY ALTERNATIVES FOR ONTARIO REMOTE COMMUNITIES

EXECUTIVE SUMMARY

Introduction and Background

This is the final report on a study undertaken by DPA Consulting Limited and Marbek Resource Consultants Ltd. on behalf of Energy, Mines and Resources Canada as part of the Remote Community Demonstration Program.

The purpose of this study is:

> "To develop a strategy and implementation plan for the Government of Canada for reduction of dependence on petroleum in remote communities* in Ontario, through the utilization of alternate energy resources and technologies and energy conservation measures."

During the course of the study it became apparent that the major direct users of fossil fuels are government institutions. Residents use some fossil fuels directly for transportation and cooking, but their largest use of energy is for space heating which is met primarily by burning wood. The Study Team perceived that there were opportunities for addressing some of the needs of residents through the energy sector, but that some of these opportunities could not easily be realized in a strategy focussed exclusively on reducing petroleum use.

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*For this study, a remote community is defined as:

- having more than 10 permanent households; and,
- not having access to the Ontario Hydro grid or a gas pipeline.
- Appendix A presents a list of remote communities in Ontario.

It was therefore agreed with the Steering Committee for the study that the scope of the strategy should be broadened to include the following objectives:

- to reduce dependence on fossil fuels in the remote communities;
- to maximize the potential for energy conservation (both wood and fossil fuels);
- to maximize the job creation and organizational development potential arising from the need to supply and/or conserve energy; and,
- to use the supply and conservation opportunities to enhance the range of services available, living conditions and life-styles in the communities.

The Study Team carried out a work program that included consultations with officials, review and analysis of the existing documentation and follow-up contacts with key oficials and data sources. Members of the Study Team also visited a number of remote communities during the study time period and had the opportunity to interview community representatives.

In analyzing the context for the strategy the Study Team drew upon the available data base to determine:

- present and projected energy consumption patterns (end-use and end-users of energy);
- renewable resource potential; and,

- technical options for the use of renewable resources and for energy conservation.

The following paragraphs outline in summary form the key findings with regard to the context for the strategy.

Context for the Strategy

Energy Consumption

Exhibit E-1 shows energy consumption by fuel type. The following points are very important in providing the context for the strategy.

- Wood accounts for 43% of total energy consumption and is used primarily for residential space heating.
- Gasoline and other fuels (kerosene, propane, etc.) account for 11% of total energy consumption, and are used for transportation, cooking, small motors, and etc.
- Fuel oil is by far the most important fossil fuel, accounting for 46% of all energy consumption, and is used largely for electricity generation and space heating.

Exhibit E-2 shows fuel oil consumption by end-use category. Clearly, space heating (39.3%) and electricity generation (52.6%) are the most imortant end-users for fuel oil.

Exhibit E-3 shows fuel oil consumption by end-user or end-user group for the two major end-uses, space heating and electricity generation. Ontario Hydro and the Department of Indian Affairs

EXHIBIT E-1: ENERGY CONSUMPTION BY FUEL TYPE

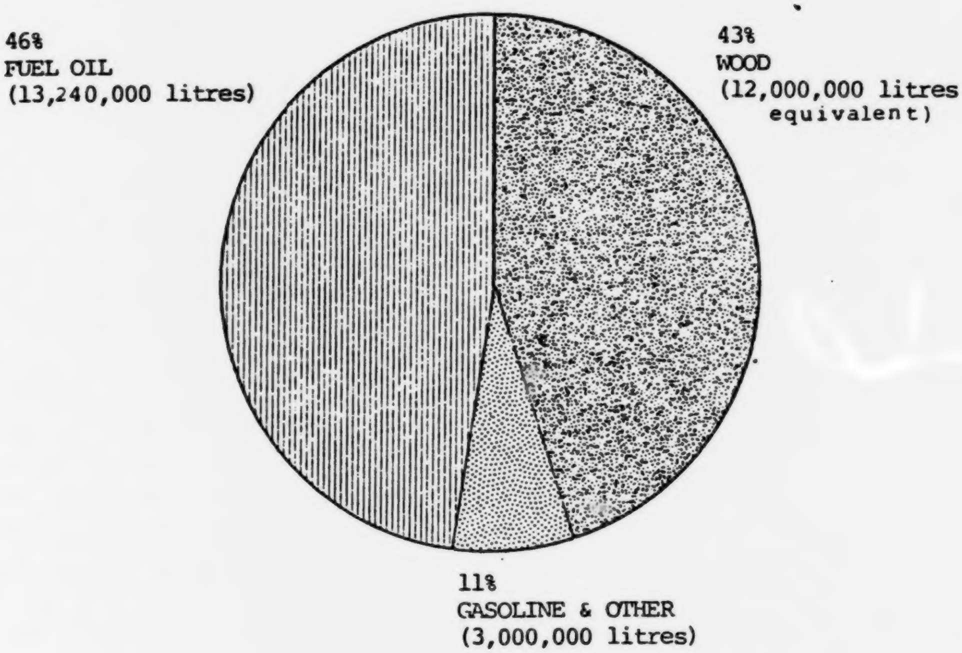


EXHIBIT E-2: FUEL OIL CONSUMPTION BY END-USE

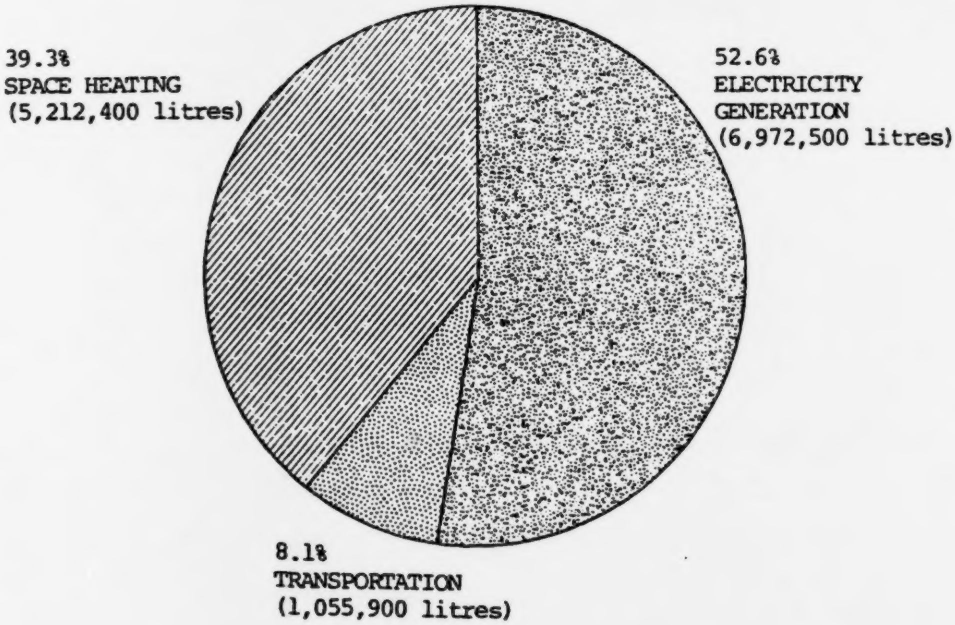
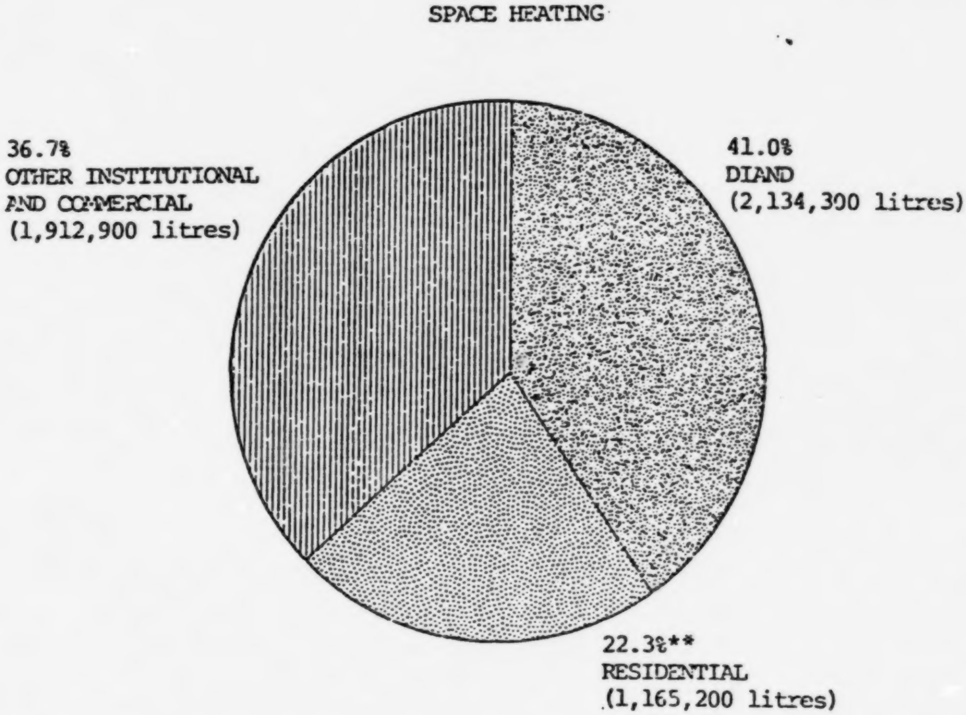
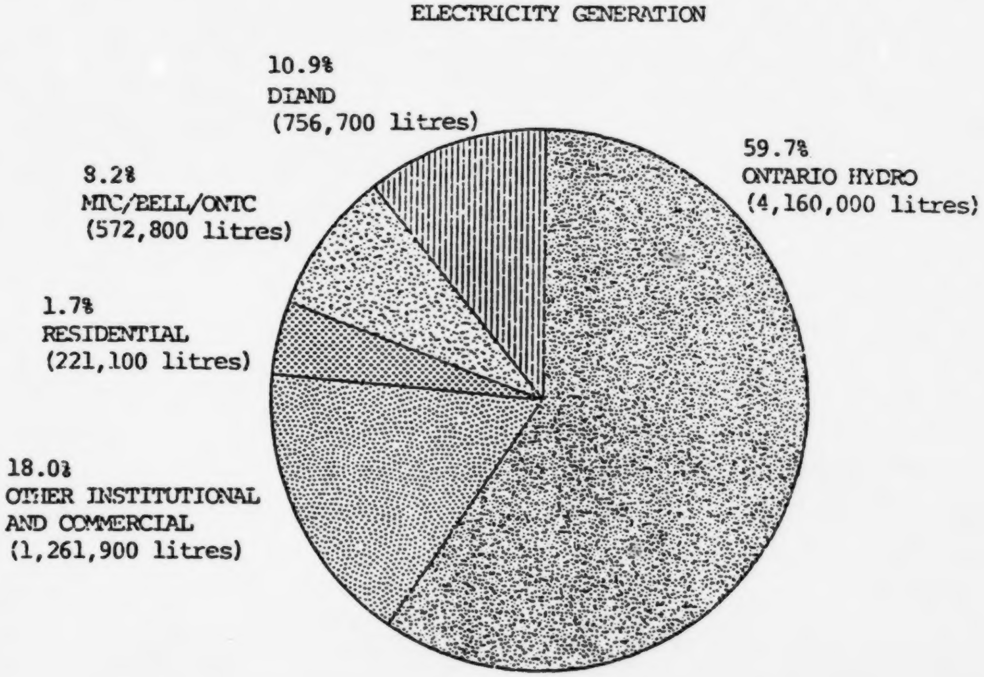


EXHIBIT E-3: FUEL OIL CONSUMPTION BY END-USER THE TWO MAJOR END-USES (1981)*


SPACE HEATING


ELECTRICITY GENERATION

* Source: The Remote Community Data Base, Ontario Ministry of Energy, 1982

** Primarily Armstrong and Ramsey Residents and Northern Development (DIAND) stand out as major end-users of fuel oil. The residential end-use of fuel oil is largely confined to the larger and more sophisticated rail communities.

Renewable Resource Potential

- The available supply of renewable resources in Ontario remote communities is significant and merits serious consideration as a fuel oil substitution option.

- Wood fuel and, in the case of the Hudson's Bay and James Bay communities, wind are two particularly important resources. Micro-hydro resources, though restricted in their availability and subject to high development costs, also represent an important local resource.

- Although peat is believed to be relatively widely available, further site specific data are required before a workable assessment can be made.

- Solar resources are adequate for passive solar heating applications as well as small-scale photovoltaic applications.

Technical Options

The Study Team assumed that to be considered eligible for inclusion in this strategy, a technical option should have a proven performance record at least in non-remote settings, and require only demonstration of its feasibility in a remote setting. The report concludes that:

- There is a wide range of technical options for energy conservation and the use of renewable resources.

- The technical options directed towards space heating (conservation) are ready for widespread implementation.

- Wind diesel hybrid systems are very close to being ready for application in those communities where wind regimes are adequate. The results of a demonstration project at Coniston should prepare the way for a demonstration project at a remote Native community on the James Bay or Hudson Bay coast.

- Small scale hydro is a proven technology but the high "up-front" costs are a major barrier given the existing decision-making framework. Feasibility studies, carried out on at least two remote sites, have shown micro hydro to be economically attractive when compared to diesel. However, these projects have not proceeded. Consequently, the most important developmental work required here is in reaching an "in-principle" policy decision that, if site specific feasibility could be shown, the capital financing would be available.

- Steam engines have a proven reliability record but their widespread use is constrained by two factors:

    - in most applications (greater than 50kW) continuous system monitoring by a 4th class stationary engineer is required; and,

    - the electrical conversion efficiency of steam engines is relatively low in comparison to other conversion technologies--in order to achieve an attractive system efficiency, it is necessary to use the waste-heat for a space/water heating application.

- Steam turbine engines are relatively efficient and reliable. However, they use high pressure steam and are generally considered to be too sophisticated for most remote community applications.
- Gasifier technology is developing rapidly but has not yet reached suitable levels of reliability for most remote, stand-alone applications.
- Wood harvesting techniques are fully developed, but to date there has been no demonstration at the required scale for alternative energy generation in a remote Native setting.
- Peat harvesting technology is commercially available, and is widely used in Europe often at a much larger scale than is required for Ontario's remote communities.

Approach to Developing the Strategy

The Study Team sought to develop a strategy which would provide a balance between intitiatives aimed at reducing fossil fuel consumption and those aimed at the social and economic objectives of the strategy and of the remote communities. The Study Team attempted to identify initiatives where the scope for Federal Government action is substantial and where the use of existing programs can be maximized.

Present and projected energy consumption patterns were the starting point for strategy development. The Study Team developed a list of energy end-use/end-user combinations and then assessed their importance for the strategy in terms of their potential for contribution to meeting the objectives of the strategy and in terms of the other considerations noted in the paragraph above.

This assessment resulted in a number of recommendations which in turn yielded the component parts or elements of the strategy. In broad terms the Study Team recommended that:

- two end-uses of energy, space heating and electricity generation, should be the focus of the strategy;
- while transportation accounts for significant consumption of fossil fuels the technical options to address this sector (e.g. vehicle design) are beyond the scope of this study;
- the greatest short-run progress in achieving objectives could be made through space heating conservation measures and heat recovery for space heating from community power diesel installations; and,
- in the medium to long-term there is considerable potential for achievement of objectives through the use of renewables to generate community power, but only after further developmental work has been completed.

Additional, more detailed recommendations are provided in the body of the report.

Elements of the Strategy

The proposed strategy consists of six elements. Each element addresses an energy end-use, an end-user or end-user category and appropriate technical options for conservation or the use of renewables. These elements are described briefly here and in more detail in the main body of the report. They are not identified in order of priority.

Strategy Element A - Heat Recovery from Community Power Installations

This element of the strategy involves improving the efficiency of diesel community power through the use of waste heat for space heating.

Strategy Element B - Community Power - Development and Demonstration of Use of Renewables

This element involves undertaking a variety of policy, developmental and demonstration initiatives aimed at creating a basis for potential medium to long term implementation of renewable technologies for electricity generation.

Strategy Element C - Space Heating of Existing Schools and Teacherages in Native Communities

This element potentially involves: energy retrofitting DIAND schools and teacherages (the largest consumer of fuel oil for space heat in remote communities); the substitution of wood for oil in school heating systems; and, the recovery of heat for space heating from DIAND diesel sets.

Strategy Element D - Space Heating - New Institutional and Commercial Buildings Design

This element involves the development and dissemination of

design standards and guidelines for Northern remote buildings. It also includes the development of standardized modular designs for types of buildings which are widely required in these communities.

Strategy Element E - Residential Space Heating In Native Communities

This element addresses improved housing in terms of energy efficiency and broader socio-economic considerations. This is a high priority for Native communities. The recommended measures involve the transfer of information and technology to assist Bands to enable them to use existing housing programs to construct more energy efficient new housing and to upgrade the energy efficiency of existing housing.

Strategy Element F - Information and Technology Transfer for Rail Communities

This strategy element addresses the potential for improved energy efficiency in space heating in the remote rail communities in Ontario in terms of the commercial residential and institutional sectors.

Implementation Plan

An implementation schedule and plan is presented in the report. Most of the activities for the first 1-5 years relate to space heating. Electricity generation alternatives, particularly those involving biomass based systems are the subject of developmental and demonstration initiatives in the 1-5 year period, with more widespread implementation as a possibility in the 5-10 year period.

Organizational Implications

In the 1-5 year period no major organizational changes will be required to support the implementation of the strategy. In the medium to long run it is envisaged that, if biomass based electricity generation systems are shown to be ready for widespread application, there may be a need for a new delivery mechanism for electricity generation.

In the 1 - 5 year period it is recommended that a capability be developed by DIAND to provide practical advice to Native communities on energy matters. The focus of this advisory service to Bands would be on: ensuring that heat recovery options are given consideration in the planning of diesels installations or major upgrades; ensuring that the potential for use of waste heat from diesels is considered in the planning of new buildings; and, assisting Bands to develop more energy efficient and appropriate housing and to renovate existing housing for improved energy efficiency, within the constraints imposed by exisiting housing programs.

National Implications

In the view of the Study Team the major implications of the findings and recommendations of this report are as follows:

- Federal Government buildings, Native housing and Federal housing programs are much the same in remote communities across Canada -- the recommendations made in this report (Strategy elements 1,3 and 4) are therefore presumeably applicable in at least the four western provinces and Quebec.

- Many of the problems associated with the use of renewables to generate electricity would be common to the four western provinces and Quebec although some of the institutional arrangements are different -- the recommended cautious approach should therefore be applicable.

- The relative limitations noted in the report with regard to the scope for Federal action in non-Native remote communities would be applicable in the four western provinces and Quebec.

QUEBEC OVERVIEW STUDY

1.0 INTRODUCTION

Energy use and renewable energy alternatives in remote communities is the primary focus of the Remote Community Demonstration Program (RCDP) of Energy, Mines and Resources Canada.

Remote communities throughout Canada have very high energy expenditures compared with more accessible areas, and most of this energy is derived from oil. Besides the cost of the oil and its transportation to remote locations, there is also the question of energy security, since there are usually fewer options and smaller margins of manoeuvre in these communities as regards alternatives to the supply, transportation and storage of oil products. The vagaries of world oil prices and oil pricing policies has done little to strenghten the tenuous linkage of international oil supply. In view of oil costs and the problem of energy security, Energy, Mines and Ressources Canada has begun to look into practical energy alternatives for electrical generation and home heating in remote communities.

Within the context of the RCDP, a remote community is one which has a year-round population of at least 12 people and which is not connected to the main provincial grid or natural gas pipeline.

This study was commissioned when it became apparent that there was no comprehensive data base on remote communities in Quebec. Because the province covers such a large area, and because there are many government organizations with responsibilities in remote areas, it was important to identify all the energy players involved, determine the scope of their responsibility and find out about their current programs and proposed plans.

This is a first attempt at a comprehensive profile of remote communities in Quebec, and there are obvious gaps. The study has therefore been designed to be put on-line so that information on energy use can be added to or updated on an ongoing basis as it becomes available.

It is hoped that this study will be useful to all who are involved in providing services into Quebec's remote communities. Our thanks are extended to all those who offered help and information and who recognized the needs of the people living in these remote communities:

Lucien Jean, Hydro-Quebec,
Pierre Fiset, Hydro-Quebec,
Rejean Prevost, Ministere Energie et Ressources Quebec,
Lorraine Brook, Makivic Corporation,
Paul Wilkinson, Naskapi Corporation,
Paul Wertman, Cree Regional Authority,
Lise Chevrier, MRC Magdalen Islands,
Line Bourdon, Energie, Mines Ressources, Montreal,

2.0 METHODOLOGY

The objective of the Quebec overview study is to provide the following information:

1. The number and location of remote communities.

2. A socio-economic profile of the community.

3. An energy-profile of the community (limited to electrical generation, home heating and renewable energy options).

4. Role of energy players primarily responsible for energy use in the remote communities

5. Options and priorities in renewable energy development in the remote communities.

The methods employed to achieve this objective were:

1. Survey of existing literature

   A bibliography of general and energy-related studies on Quebec remote communities was prepared. The communities were then grouped into four ecoregions: each one distinguished by its geological, biophysical and climatalogical characteristics. In addition, each ecoregion has particular cultural and linguistic features.

   It was found that some ecoregions had more complete and up-to-date data bases than other. It was therefore decided to prepare a standard format of socio-economic and energy profiles for each community. This would facilitate the comparative analysis of communities and ecoregions, as well as simplify the computerization of data and subsequent data analysis.

2. Consultation with groups of remote communities through their regional governments

   Background information on the RCDP was sent to various regional governments and remote community associations in Quebec. This was a way of saving time and still contacting the RCDP end-users or clients - the remote communities. Telephone calls were then made to arrange meetings with officials so that further information could be obtained. This also enabled representatives of the various governments and associations to express their interests and concerns regarding the issues involved, and it gave them time to analyse their participation and inform their communities of the program.

3. Contacts with the provincial government and para-government organizations

Interviews were scheduled at the Quebec Department of Energy and Resources, Hydro Quebec and other organizations to provide briefings on RCDP and to discuss common areas of interest in program objectives. In view of the large number of provincial departments and organizations responsible for energy use in remote communities, a questionnaire was sent asking these organizations to describe their roles and responsibilities with regard to energy use and to evaluate a list of criteria which could be used to judge the merit of proposals received for funding under the RCDP.

4. Contacts with federal departments

Scheduled interviews and the same questionnaire that was sent to provincial players were used to determine the nature of federal involvement and interest in energy use in remote communities.

ENERGY OVERVIEW STUDY FOR REMOTE COMMUNITIES IN NEWFOUNDLAND

Executive Summary

The Remote Community Demonstration Program was introduced in 1982 as part of the federal government's oil-off initiatives. The program is designed to promote the awareness and adoption of alternative-to-oil energy sources and energy conservation practices in remote communities in Canada.

To help in the operation and future planning of the program, Energy, Mines and Resources Canada commissioned this "overview" study to identify and profile remote communities in Newfoundland and Labrador which are eligible under the program, and to identify alternative energy sources and energy conservation options open to these communities.

Basically, the program defines a "remote community" as one that has at least 10 permanent residences, at least five years of planned life remaining and is not now connected to or firmly committed to connection with piped natural gas or main electrical grids.

In applying the definition to Newfoundland, it should be pointed out that no natural gas is produced or consumed in the province.

The study identified 79 Newfoundland and Labrador communities serviced by 39 isolated diesel generating plants as eligible under the program. These communities have 29,969 inhabitants, or 5.3% of the province's total population.

Obtaining data on these communities was extremely difficult. Except for a limited number of incorporated communities which have received funding to undertake municipal planning work, the data base on many communities in either non-existent or difficult to obtain.

Data on energy consumption in these communities, though incomplete, is estimated at 1,558,486 GJ. The study points out that, even if actual consumption is two or even three times higher, remote community energy consumption still does not account for more than 2-4% of the provincial total.

Each community is profiled by location, population, history and current status, community services and facilities, economic activities, communications and transportation links, and diesel electric generation information.

An assessment of likely alternatives to oil for both electricity and space heating has been done for each of the 39 centres. A load centre is defined as the location of a diesel generation station, containing one or more diesel generation units, from which one or more communities are served with electricity. Briefly, the conclusions are:

- small scale hydro is probably viable for nine load centres.
- many of the communities where wood is accessible already make extensive use of it. However, it is likely that the potential exists for further exploitation of fuelwood in many of these communities.
- the generation of electricity from wood using gasification technology shows some promise.
- based upon the scanty data available, it appears that peat is competitive as a solid fuel for use in stoves at a harvesting cost of up to $1.50 per cubic meter.
- Newfoundland does have substantial potential for the application of wind energy technology and, as the technology matures, it will likely find numerous applications in remote communities.
- the recovery of the waste heat from the cooling water of the diesel generating plant may be a viable option in some communities.

SECTION 2

ALTERNATIVE METHODS OF SUPPLY

KLONDIKE NORTH FORK HYDROELECTRIC GENERATION REDEVELOPMENT NEAR DAWSON, Y.T.

EXECUTIVE SUMMARY

A preliminary study of the feasibility of generating electric power for the community of Dawson, Yukon Territory by redeveloping the Klondike North Fork generating station has been carried out. Partial funding for the study was provided by the Government of Canada as part of the Remote Community Demonstration Program which seeks to demonstrate oil reduction or displacement technologies which will improve the quality, price or security of energy supplies in remote Canadian communities.

The objective of the study was to establish whether, under present day conditions, there might be an opportunity for cost savings in electricity supply by redeveloping part of the Klondike North Fork hydroelectric project.

Environmental, socioeconomic, land rights and regulatory issues would influence redevelopment of the project. These were set aside at this preliminary stage in order to quickly establish whether any sort of redevelopment might be attractive and what general form a feasible redevelopment might take.

The Klondike North Fork power project was developed in 1910 and 1911 and eventually was expanded to a 10 500 kW capacity. The project included a power station with a gross operating head of approximately 69.5 m. Water was supplied by a 4.6 km long canal from a diversion point on the North Klondike river and by a second canal extending a further 26 km to a diversion point on the Klondike River. The electric power which was generated was primarily used by the large dredges which mined the gold bearing gravels in the Klondike River valley. Power was also supplied to Dawson. Under winter conditions, the capacity of the powerplant was reduced to an average of 2500 kW due to the lower river flows available. That reduced output was sufficient to meet the electricity needs of the community including a significant energy consumption for water heating. At the beginning of winter, extreme efforts by large maintenance crews were needed to prevent ice from blocking the canals and causing a complete interruption of power supply. The power plant operated until 1967. Since then, Dawson has been supplied with electrical power from a diesel generating station in the town. Heating of the water supply and some space heating has been achieved using waste heat from the diesel engines.

Redevelopment of the project would involve replacement of the intakes, key spillways, and the penstocks. Minor spillways which were previously used to divert slush ice would be abandoned. The canals would be cleared of vegetation

and minor bank repairs effected. Fourteen check weirs would be added to the canals to reduce water velocities. With suitably low flow velocities in the canals, an ice cover would develop easily at the beginning of winter ensuring reliable water conveyance to the turbines throughout the winter months.

The North Fork Diversion Dam would be rehabilitated and a new spillway and intake structure provided. A new weir would be required to divert water into a new South Fork Intake. Provision has been allowed in the cost estimates for the cost of providing a passage for fish past each of these diversion structures.

For the purpose of the study, it has been assumed that one or two new 1000 kW turbine-generator sets would be installed in part of the existing powerhouse. A new transmission line would be built to Dawson making use of some existing poles and right-of-way.

Three development scenarios were considered. The first two would use flows from the North Klondike River only and would not require construction of the costly South Fork diversion structure or rehabilitation of the South Fork canal and structures. Installed capacities of 1000 and 2000 kW were considered. This has been named the 'North Fork Development'. The third would include the South Fork installations and would exploit the combined flows from the Klondike River and its tributary, the North Klondike River. This has been named the 'North and South Fork Development'. The production of electricity and estimated capital costs for each alternative is summarized in the following table.

ENERGY GENERATION AND ESTIMATED COST OF ALTERNATIVE DEVELOPMENTS

Development	Installed Capacity (kW)	Average Output (kW)	Minimum Output (kW)	Proportion of Time Full Capacity Available (%)	Estimated Capital Cost ($ million)
North Fork	1000	989	623	92.6	5.1
North Fork	2000	1685	623	57.2	6.0
North and South Fork	2000	1999	1916	99.6	9.6

The economics of redevelopment have been assessed in terms of the value of fuel costs which could be displaced at the diesel generating station in Dawson. Peak electrical generation in 1984 varied through the year from 1147 to 1436 kW and the total energy requirement for the year amounted to 8234 MW.h, equivalent to an average output of 940 kW. A base case of future electricity requirements has been estimated using 1.6 percent per year growth based on forecasts by the Northern Canada Power Commission.

The fuel savings have been assessed on a month-by-month basis by matching the average generating capability of the hydroelectric plant with the forecast demands over a 30 year period. The energy needs of water heating have been accounted for using electricity, oil fired heating or waste heat from diesel generation as most appropriate. Predicted net fuel savings are as follows:

PREDICTED FUEL SAVINGS - litres per year

Development	Annual Fuel Saving - Millions of Litres	
	Fuel Savings First Year	Fuel Savings 30th Year
North Fork 1000 kW	1.9	1.9
North Fork 2000 kW	2.4	3.2
North and South Fork 2000 kW	2.5	3.7

ECONOMIC ANALYSIS

Economic analyses were carried out to compare the costs of meeting the projected electricity and heating requirements with and without the hydroelectric redevelopment. The following table summarizes the base case results:

Development	Base Case 1984 Net Present Value of Savings ($ millions)
North Fork 1000 kW	3.2
North Fork 2000 kW	5.9
North and South Fork 2000 kW	3.3

- Present value of diesel fuel savings less hydro costs over 30 years calculated with a discount rate of 13 percent per year.
- General inflation rate of 5 percent per year.
- Load growth at a rate of 1.6 percent per year.

Various rates of load growth, rates of escalation of fuel prices and discount rates were considered in sensitivity analyses. A net saving was predicted for all redevelopment alternatives for all conditions tested. The study has not, however, addressed the impact of the development on the electricity rates.

It is concluded that redevelopment of a hydroelectric station using parts of the old Klondike North Fork development offers an opportunity to realize significant savings in future electricity costs.

It is recommended that a preliminary study be undertaken to address environmental, socioeconomic, land rights and regulatory issues. If the results of that preliminary study prove to be favorable, it is recommended that a feasibility study be undertaken to:

(a) obtain more complete field data, and develop designs in more detail so that:

  - the most attractive staging of the redevelopment can be decided
  - the development plan accommodates environmental and other requirements
  - the cost estimates can be established at a level of certainty to support investment decisions;

(b) set out a phased plan of development which will maximize the expected savings by providing for flexible expansion of the hydroelectric capabilities in response to future increases in electricity demand or fuel prices.

This report refers to the North Fork and South Fork of the Klondike River. The official names of these rivers are now, respectively, North Klondike River and Little South Klondike River.

MORLEY RIVER HYDRO

SUMMARY

The objective of this study was to investigate the economic feasibility of a 500 kW hydro installation on the Morley River in Yukon. The site is approximately 3 km downstream of the point at which the Alaska Highway crosses the river and 50 km southeast of Teslin. The hydro plant would serve Teslin which is now using diesel generated electricity. A secondary objective of the project would be the displacement of 500 k litres of diesel fuel per annum by hydro power.

Basing the investigation on a 500 kW plant an average of 4.3 GWh of energy would be available per year. However, the demand is only 1.715 GWh/a and the peak power demand is 390 kW. Assuming no load growth and no real diesel price increases a 500 kW project is not economic over the long term (10 years).

If a 2% annual increase in either load growth or diesel price is assumed the economics are marginally favourable over the long term and if both factors increased 2% per annum the long term benefits are significant. For this case; however, the short term economics are still unacceptable by the standards of the Yukon Electrical Company Limited.

SUMMARY - VOLUME 1

SMALL HYDROELECTRIC DEVELOPMENT STUDY

NORTHWEST TERRITORIES

This Study was undertaken to identify and test the feasibility of small hydroelectric plants, or alternative energy sources, in replacing or reducing the use of oil in six communities in the Northwest Territories. The six community, which are located between 62°N and 68°N Latitude and 68°W and 122°W longitude, Figure 1.1, are Baker Lake, Coppermine, Fort Simpson-Trout Lake, Frobisher Bay, Rae Lakes and Rankin Inlet, and they presently obtain electricity from diesel generators and heat by the combustion of oil or wood.

As a first step towards solving this problem, load forecasts were prepared for a 40 year period. The forecast was based on

- population and its projected growth;
- consumption of electrical energy per capita;
- consumption of oil for heating;
- temperature variations in the coldest month.

The basic forecast was adjusted to produce five scenarios, which took into account conservation measures and an improved lifestyle. The five scenarios are:

- extension of the present electrical demand, with and without energy conservation;
- extension of the existing electrical load plus heating requirements, with and without energy conservation;
- extension of the existing electrical demand increased for improved lifestyle and heating requirements and decreased by energy conservation. This is the medium combined load.

The hydroelectric sites were selected to meet a number of conditions, namely

- they should be operational all year round, and storage should be available if necessary;
- their capacity should be sufficient to meet both the projected normal electric load and the heating load, but the smallest acceptable capability would be that of meeting the projected normal electric load;

- the site should not normally be more than 25 km from the load centre to reduce transmission line costs. For Fort Simpson, the transmission distance of the most suitable site was about 120 km from the load centre;
- because of climatic conditions the water conveyance system should be as short as possible.

Site specific hydrologic data was not available for all of the sites, and the analysis was therefore done on a regional basis. The regional analysis was used to produce average river flows and flood flows.

The study was divided into three phases, each phase using somewhat better information than the preceeding one. In the first phase, head differences were obtained from topographic maps to a scale of 1:250 000 with 30.5 m (100 ft) contour intervals. In the second and third phases of the study, the available heads were based on field measurements.

In the first two phases of the study, the cost effectiveness of a hydroelectric scheme was obtained by comparing the effective cost of energy from the hydro plant with the weighted cost of energy from the existing diesel generating and oil combustion systems. This comparison gave a cost index for the project. The effective cost of hydro energy was based on the annual cost of the hydro plant and the actual energy consumed, as given by the load forecast. The annual cost took into account amortization, depreciation, replacement, and operation and maintenance costs. The weighted cost of the existing systems reflected the cost of diesel energy and the cost of heating. The costs which were used in these calculations were all present values in 1984 dollars.

In the last phase of the study, cost streams for the amortization and operation of a hydro-diesel system and an all diesel system were present valued and compared. The resulting analysis, which was done by a computer, gave benefit-cost ratios, internal rates of return, cost of energy, optimum plant size, optimum time of commissioning the hydro plant, and the time period to recover the initial investment on the hydro plant.

The only practical alternative energy source which is compatible with the load, climate in the communities and the state of technological development, is wind energy. This alternative was investigated briefly for all of the communities with the objective of meeting the normal electric load only. However, wind generators must be used in a hybrid system to provide acceptable system reliability. For heating, alternative energy sources are gas and wood.

The main results of the investigations which were carried out for each community are as follows.

BAKER LAKE

Two schemes satisfied the criteria outlined above, but only the scheme on the Thelon river advanced to the second phase of the study. The scheme consisted of an 11 m high overflow, rockfill dam across the Thelon river near Tupik Lake and an underground powerhouse in the left bank of the river. Plant flows varying from 143 m^3/s to 198 m^3/s were investigated, i.e., plant capacities varying from 5,6 MW to 10,1 MW, respectively were analysed. The energy from the plants varied from 46,7 GWh p.a. to 84,3 GWh p.a., respectively, and could therefore meet both the normal electric load and the heating load.

The hydro plant most likely to compete with the existing system was the 5,6 MW alternative which was estimated to cost $56,7 millions with a cost margin of ± 20%. At 80% of the capital cost and using a discount rate of 6% p.a., the effective cost of energy was found to be 14,0 ¢/kWh. When compared to the weighted cost of energy from the existing system at 11,6 ¢/kWh, it was clear that the hydro project was not economically viable.

The main reasons contributing to the high hydro energy costs were:

- the small load and hence the under-utilisation of the potential of the site;
- high civil works costs caused by the relatively large size of the Thelon river;
- the need to create head by constructing a dam;

Wind energy appears to show promise as an alternative energy source for Baker Lake. The cost of wind energy, based on preliminary wind data, was estimated at 16,0 ¢/kWh at 6% discount rate. However, before any final statement can be made on the suitability of wind generators, basic site specific wind data should be collected over a period of at least one year.

COPPERMINE

This hydro project for this community at Bloody Falls in the Coppermine river, was the only one which was studied in some detail. One site on the Kendall river and another at Escape rapids, Coppermine river, were inferior to the Bloody Falls site. The project consists of an interception trough in the river just upstream of the falls, an intake, 5,4 m diameter power and tailrace tunnels and a semi-underground powerhouse in the left bank of the river. The optimum plant size uses 46 m^3/s under a head of 5,0 m to produce 1888 kW of firm power, i.e., the plant uses less than the estimated minimum flow in the river without the use of a dam.

This plant, which is estimated to cost $16,1 millions, would be used primarily to meet the normal electric load. Excess energy could be used for heating. However, since there is only one hydro unit, the existing diesel plant was assumed to be retained to maintain the reliability of the system, but run only nominally. The cost of this hydro-diesel system was compared to an all diesel system at a decision discount rate of 8% p.a.

For the all diesel system, energy is produced at 37,8 ¢/kWh, while energy from the hydro-diesel system is obtainable at 33,6 ¢/kWh, when excess energy is used for heating. When the excess energy is not utilised, the cost is 43,4 ¢/kWh. In the case of full use of the hydro energy, the pay back period is 20 years with a benefit cost ratio of 1,17; for no use of the surplus energy the pay back period is extended to 40 years. For a 20% increase in the capital cost, the benefit cost ratio is reduced to 0,93% at the decision discount rate.

Wind as an alternative energy source was not found to be attractive, because of the low wind regime. At 8% p.a. discount rate the cost of wind energy is 43,4 ¢/kWh.

The development of the Bloody Falls site is contingent upon proper environmental studies being undertaken, especially with respect to arctic char. This fish is an important source of protein to the community, and any development which would adversely affect the fish would be unacceptable. As the project is presently designed, it is believed that there is little adverse environmental impact on the project.

FORT SIMPSON - TROUT LAKE

The only suitable hydro site was found on the Trout river. The proposed development consisted of headworks at the outlet of Trout Lake, an upstream power plant about 35 km downstream of the lake, and a second power plant near Whittaker Falls. The project design requires spring and summer flows to Trout Lake to be stored for release during the winter.

Both powerhouses have a maximum plant flow of 39,2 m^3/s. The upstream plant has a capacity of 8,5 MW and the net head is 26,6 m, while the downstream plant has an installed capacity of 5,5 MW under a smaller net head of 17,9 m. The energy from both plants can satisfy both the normal electric load and the heating load for 30 years.

Energy would be transmitted to Fort Simpson, 120 km away from the downstream plant, and to Trout Lake 68 km away from the upstream plant. The estimated capital cost of the project was $58,8 million and the effective cost of energy was found to be 8,7 ¢/kWh. This cost is more than the weighted cost of the existing systems, namely 7,9 ¢/kWh, both at 6%

p.a. discount rate. Hence the Trout river developments are not competitive with the existing system. It must be noted here that the main reason for the project not attaining economic viability is due to the long transmission lines, and is not due to any intrinsic deficiency of the hydroelectric sites.

Wind as an alternative electric energy source was not found to be possible because of the low wind speeds in the area.

FROBISHER BAY

This study primarily reviewed and revised the findings of earlier work done on potential hydro sites on the Sylvia Grinnell river. The proposed project consisted of a control structure at the outlet of Sylvia Grinnell lake which would be used to store spring and summer flows. These flows were then to be released to a downstream power plant about 10 km from Frobisher Bay. Since there was no natural head, a 56 m dam was proposed along with a spillway and powerhouse with an installed capacity of 7,5 MW.

The estimated cost of this development, which could provide energy to meet only the normal electric load for about 40 years, was $94 million. The effective cost of energy was found to be 20,6 ¢/kWh at 6% p.a. discount rate, and it compared unfavourably with the cost of diesel energy at 19,5 ¢/kWh.

A serious disadvantage of this project is the construction of a 56 m high dam, on a river which has a relatively small runoff. It would therefore appear that the existing systems for heating and producing electricity provide, at this time, the optimum solution to the energy needs of Frobisher Bay.

RAE LAKES

Three hydro schemes were investigated for this community, one at the outlet of Faber Lake, a second at the outlet of Lac Ste Croix and the last between Rae Lake and Taka Lake. The best scheme was the Rae Lake/ Lac Ste Croix project which required a small overflow dam and intake between the two lake systems, a short canal and a powerhouse at Lac Ste Croix. The turbines used 9,2 m^3/s under a net head of 5,4 m, and the power plant had an installed capacity of 250 kW. The energy which was produced could meet total energy demand, but not the peak power demand.

The estimated capital cost of the selected scheme was $4,4 million and the effective cost of energy was found to be 17,6 ¢/kWh at 6% p.a. discount rate. When compared with the weighted cost of energy from the existing systems, namely 10,8 ¢/kWh, it became clear that the project was not economically viable.

Wind as an alternative energy source was found to be more expensive than the energy from the diesel plants. Wind energy was estimated to cost 62,7 ¢/kWh at 6% p.a. discount rate, while the cost of diesel energy was 27,2 ¢/kWh.

RANKIN INLET

It was found that any hydro development in the Rankin Inlet area could only provide enough energy to meet an electric load. The project which was investigated was on the Diana river. The intake was located near the outlet of Diana Lake and water was conveyed by a canal; part of the canal system utilised three lakes. The gross head which was obtained was 10,8 m and the plant flow was taken to be 27,9 m^3/s.

This plant flow was based on the assumption that water from Gibson Lake could be transferred to Diana Lake; the Gibson catchment contribution forms nearly 70% of the plant flow.

Subsequent field surveys were able to indicate that the possibility of transferring water from Gibson Lake to Diana Lake was quite low. This was due to the relatively high terrain between the two catchments. Consequently, the project became technically not feasible.

Wind as an alternative energy source was investigated, and the estimated cost of wind energy is 17,0 ¢/kWh compared to 23,1 ¢/kWh for diesel generation. This estimate is based on the wind regime at Chesterfield Inlet, and it is therefore necessary to obtain site specific data. This data should be collected over a period of one year.

CONCLUSIONS

It must therefore be concluded that the development of small hydroelectric plants to displace oil is not viable for Baker Lake, Fort Simpson-Trout Lake, Frobisher Bay, Rae Lakes and Rankin Inlet. At Coppermine, the Bloody Falls scheme may be marginally economical, but a full feasibility and environmental study would be required to confirm this. Wind as an alternative energy source is worth further investigation at Baker Lake and Rankin Inlet.

SUMMARY - VOLUME 2

SMALL HYDROELECTRIC DEVELOPMENT STUDY

NORTHWEST TERRITORIES

This report describes the pre-feasibility level assessment of possible hydroelectric development near Coppermine, NWT. This study is part of a larger program that considered small hydro projects at six communities in the Northwest Territories, as described in the main study report volume.

This study was undertaken on behalf of the Northern Canada Power Commission (NCPC) with the objective of locating a hydroelecrtric site that could be developed to supply energy to the small Inuit community at Coppermine. The hamlet of Coppermine is located on the northern coastline of mainland Canada at the mouth of the Coppermine river. The construction of a hydroelectric plant in the area, which is north of the arctic circle, would therefore make this plant the most northerly hydroelectric development in Canada.

There are about 890 people in Coppermine most of whom are Inuit. The lifestyle of the community is largely traditional although this is changing. The community is located in a zone of continuous permafrost and above the tree line. Average monthly temperatures vary from -30,1° C, in January, to 9,7°C in July. Temperatures are below freezing for 8 months of the year. Because of the geographic location of the hamlet, daylight hours vary from zero to 24 hours.

Presently, the community is supplied with electricity generated by a diesel generating plant which has an installed capacity of 1575 kW. In the fiscal year 1983/84, 2,66 GWh of electricity were generated and the peak load was 620 kW.

As might be expected, heating is required all year round, although the summer heating requirement is small. Space heating is provided by the direct combustion of home heating oil.

The initial objective of the study was to develop a hydroelectric plant which would meet both the normal electric load and the space heating load. However, as the study developed, economic assessments dictated that only the projected normal electric load should be met, and that excess energy would be available for heating. The projected normal electric load at the end of the ecomonic life of the hydro plant was estimated to be about 8,0 GWh p.a.

Based on previous work which was done, three hydroelectric sites were examined. One was located on the Kendall river near Dismal Lakes, and two on the Coppermine River. These two latter sites were Escape Rapids and Bloody Falls. The Bloody Falls site was found to be the best for the following reasons:

- it is located closest to the community, and would require a transmission line of about 15 km;
- there is a natural head of about 6m;
- the Coppermine river does not freeze to the bottom during winter.

Examination of the site evolved from a desk study using 1:250 000 scale maps to one based on field measurement of the gross head at the falls. Based on the information obtained during the field visit, a new topographic map to a scale of 1: 2 500 was prepared using existing air photographs. Geotechnical evaluation of the site was based on a ground reconnaissance and on photo-geological interpretation of the area.

The evaluation of available flows at the site was based on a regional estimate of runoff in the Northwest Territories. There was also limited information on flows at Coppermine, since Water Survey of Canada had erected a gauging station just upstream of the falls in 1983.

The first layout of the project consisted of a dam and intake upstream of Bloody Falls, a tunnel and the powerhouse at the downstream end of the falls. This configuration was later changed to remove the environmental problems which would be created by the dam. These problems centered principally around the fish population in the river. It was necessary to ensure that the migratory pattern of the arctic char and other fishes, which provides about 32% of the diet of the Inuit, was not disturbed.

The present layout consists of an intercepting trough which is excavated in the river bed and thus allows flows to be diverted to a semi-underground powerhouse via an intake and a 5,4 m diameter concrete lined tunnel. Water is returned to the river by a tailrace tunnel of the same diameter as the headrace tunnel. Four schemes with capacities varying from 922 kW to 2800 kW were investigated. The selected scheme, based on the economic analysis, is one with rated output of 1888 kW. However, a nominal 2 MW plant can be installed. There is only one generator driven by a Kaplan turbine.

The selected plant utilises a flow of 46 m^3/s under a net hed of 5,06 m. Since the minimum flow in the Coppermine Riiver at Bloody Falls is estimated to be 58 m^3/s, the average energy production is the same as the firm energy output. The rated energy output from the plant is estimated to be about 15,8 GWh p.a. The estimated capital cost of the project is $16,066 million, in 1984 dollars, excluding the cost of a feasibility and environmental studies. It is estimated that these studies would cost an additional one million dollars.

Construction of the project is estimated to take 34 months. Although the critical construction item is the manufacture and delivery of the generating equipment, the construction of the diversion trough must be done in two seasons since there would be no cofferdam across the river. The contruction of the trough is done during the periods of low flow.

The evaluation of the project was made by comparing system capital and operating costs with and without the hydro plant. The analysis was made with real discount rates of 6%, 8% and 10%.

The analysis considered that the hydro energy in excess of the normal electric load demand would be utilised for space heating. The value of the energy used for heating was taken as 6,4 ¢/kWh, which is 90% of the equivalent electrical cost of home heating oil. It was shown that at the decision discount rate of 8% p.a. the hydro plant would yield a benefit cost rates of 1,17. When the cost of the project was increased by 20%, it was found that this reduced to 0,93 and the internal rate of return was 7,9%. Based on the estimated cost of the project, the cost of energy at the decision discount rate was estimated as follows:

Diesel generating system	37,8¢/kWh
Hydro-diesel system	33,6¢/kWh
Hydro generation costs	31,7¢/kWh

The payback period was found to be 20 years and the optimum year of installation is 1992.

If the excess hydro energy is not utilised, it was found that the cost of energy from the hydro-diesel system was 43,4¢/kWh at the decision discount rate. Also, the payback period would be extended to 40 years.

The environmental impact of the project would be small, since there is no structure aross the river. However further studies, particularly relating to fish life in the river, would be required.

The possibility of using wind as an alternative energy source was also examined briefly. But it was not found to be a viable proposition.

A feasibility study would be required to confirm the technical and economic viability of the Bloody Falls project. Environmental studies relating to the fish life in the river are a prior requirement of any feasibility study.

SMALL HYDROELECTRIC DEVELOPMENT STUDY, NORTHWEST TERRITORIES

CONCLUSIONS

This study was undertaken to identify and test the feasibility of small hydroelectric plants, or alternative energy sources, in replacing or reducing the use of oil in six communities in the Northwest Territories. The six communities, which are located between 62°N and 68°N Latitude and 68°W and 122°W Longitude, Figure 1.1, are Baker Lake, Coppermine, Fort Simpson - Trout Lake, Frobisher Bay, Rae Lakes and Rankin Inlet, and they presently obtain electricity from diesel generators and heat by the combustion of oil or wood.

Hydroelectricity as an alternative source of energy was found to be potentially viable for only one community, namely, Coppermine. The project at Blody Falls, Coppermine River, may be marginally viable but a full feasibility level and environmental study would be required to confirm its economic viability. For the other communities, the hydro projects were not viable because of a combination of the size of the load, the length of the transmission lines, the lack of enough river flow, lack of head or fall in the river, and the size of the river.

The only other abundant source of energy available locally to produce electricity is wind. Since the present state of wind power technology has yet to provide a cheap method of storing electricity, the intermittent nature of wind necessitates that wind turbines be installed in conjunction with another more reliable power source such as diesel or hydro generators. Therefore, the prime benefit of a wind turbine in conjunction with a diesel generator electrical system is its ability to replace diesel fuel. A preliminary investigation has shown that further studies of a wind-diesel system may be warranted for Baker Lake and Rankin Inlet. However, present indications are that such a system may be marginal and site specific wind data is needed for a period of at least one year at each of these communities.

It must be concluded that, at the present time, the production of electricity by diesel generators is the best option for Fort Simpson-Trout Lake, Forbisher Bay and Rae Lakes. Also, the combustion of oil or wood, as presently occurs for space heating, cannot be replaced by hydroelectricity on a competitive basis. However, where there is a possibility of using natural gas in the future, the cost effectiveness of this energy source for space heating and electrical generation should be investigated.

SUMMARY

The status of the existing diesel electric generating stations at Bamfield and Shearwater is examined in this report and the costs of energy from these stations are compared with the alternative energy sources which could be developed in these areas. The report is divided into four parts. The first part includes the Summary, Recommendations and Terms of Reference. The second part (Part A) describes alternative energy options as they apply to Bamfield. The third part (Part B) describes alternative energy options as they apply to Bella Bella. The fourth part (Appendices) describes the status of alternative energy technologies, background information on the cost estimates and a glossary of technical terms and abbreviations to assist the reader.

PART A - BAMFIELD

In 1982/83 the peak load and annual energy for the Bamfield diesel generating station were 0.65 MW and 3.14 GW·h respectively. For this report it was assumed that the peak load would continue to grow at 5.3 percent per annum and the energy demand would grow at 5.0 percent per annum. As a result, the projected peak load in 1990/91 would be 0.98 MW and the corresponding annual energy would be 4.65 GW·h. It was also assumed that these growth rates would continue unchanged thereafter.

All cost estimates are stated in terms of March 1984 dollars. Gross unit energy costs are based on the projected 1990/91 load. In estimating payback periods, it is assumed that the cost of diesel fuel will increase at the rate of inflation until 1986/87 and rise at 1 percent net of inflation thereafter.

The estimated costs of energy from the alternative energy sources near Bamfield are compared in the following table and they are examined in detail in Part A, Section 7.0 of this report. The results of this preliminary evaluation of the alternative energy sources potentially available to Bamfield are as follows:

1. Energy sources which could provide economical alternatives to diesel power generation at Bamfield (based on gross unit energy cost):

   a. Small Hydroelectric Generation at Sarita River - The unit energy cost from a 1.0 MW hydroelectric generating station on the Sarita River, 19 km from Bamfield, is estimated to be 104 mills/kW·h. Small hydroelectric generation could provide an estimated 4.65 GW·h of energy in 1990/91 and as much as 6.1 GW·h/a when demand is higher in the future. The size of the plant would be limited by low summer flows on the Sarita River.

Small hydroelectric power generation alone could not supply all of the electrical energy required in the future and supplementary diesel generation would be required in order to serve the increasing demand and particularly the peak load. The addition of the supplementary diesel generation would increase the unit energy cost in 1990/91 to 127 mills/kW·h. The payback period for the small hydroelectric/diesel combination is estimated to be more than 20 years based on a 1990/91 in-service date.

The environmental impacts of a small hydroelectric development would not be significant because the level of Sarita Lake would not be raised and the generating station would be located at the upper limit of salmon migration.

b. Distribution Line From Port Alberni (China Creek) - A 25 kV, 3-phase distribution line has been proposed from China Creek to Bamfield. The line would be 73 km long, generally follow the existing logging roads and could be completed by 1986/87. It is estimated that this line could provide an economical alternative to diesel power generation at 118 mills/kW·h in 1990/91. This is more than the estimated cost of small hydroelectric generation, but distribution could provide for substantial growth at decreasing unit energy cost in the future, whereas the small hydroelectric alternative has limited growth potential.

The payback period for a distribution line from China Creek is estimated to be 12 years, which is appreciably less than the payback period for small hydroelectric generation.

A distribution line could be constructed along the existing access road from Port Alberni to Bamfield with little environmental impact. There would be some loss of forestry values because of land alienation along the right-of-way.

2. Energy sources which would be less economical than diesel power generation at Bamfield (based on gross unit energy cost):

a. Tidal Power Generation at Bamfield Inlet - The potential for a 500 kW tidal generating station on Bamfield Inlet was examined briefly as a potential source of electrical energy for Bamfield. The proposed tidal generating station could only supply 1.4 GW·h/a because of the low capacity factor and low tidal range. The gross unit energy cost is estimated to be 416 mills/kW·h, which is substantially more than the cost of diesel generation. In addition, tidal power is intermittent, but predictable, so it could only be considered as a fuel saver. Diesel generation or another dependable source of electrical power would be required for back-up.

COMPARATIVE ENERGY COSTS[*1] - BAMFIELD

	Diesel Bamfield	Small Hydroelectric Sarita River	Tidal Bamfield Inlet	Wind Pachena	Thermal			Distribution Port Alberni - Bamfield
					Wood	Wood-Gas	Coal	
					Roquefeuil Bay			
Plant Capacity (MW)	1.7	1.0	0.5	0.30	1.0	1.0	1.0	1.8
Annual Energy (GW·h)	4.65	4.65	1.40	0.16	4.65	4.65	4.65	4.65
Project Cost ($/kW)[*2]	710	5903	14 374	4643	6476	5116	5793	1993
Total Capital Cost (k$)[*3]	1207	6505	7927	1518	7255	5686	6411	3911
Equivalent Fuel Cost (mills/kW·h)	117	-	-	-	68	89	29	-
Gross Unit Energy Cost (mills/kW·h)	161	104	416	872	253	232	193	118
Payback Period (a)	-	>20	-	-	-	-	>20	12

[*1] 1984 dollars at a 4 percent net discount rate.

[*2] Includes construction, engineering and contingency costs.

[*3] Includes construction, engineering, overhead and I.D.C. costs.

The environmental impacts of tidal generation on Bamfield Inlet could be considerable. Access to a proposed marina and to a few residences up the inlet from the barrage would be blocked by a tidal development.

b. Wind Power Generation near Pachena Bay - In 1981 the National Research Council and B.C. Hydro constructed a wind monitoring station on a hill overlooking Pachena Bay. In this study that site was selected for a 300 kW wind farm using six 50 kW vertical axis wind turbines. It is estimated that a wind farm of this size could only produce 160 MW·h/a of electrical energy because of the adverse wind regime. On this basis the gross unit energy cost is estimated to be 872 mills/kW·h. Wind is intermittent; therefore, wind generators could only be used as diesel fuel savers. Diesel generation would be required most of the time which would further increase costs.

The principal environmental impact of wind generation would be the land alienation. The land required for this wind farm would be approximately 9 ha and this land would be unavailable for forestry development which is the present land use.

c. Wood-Fired Thermal Power Generation at Roquefeuil Bay - A wood-fired thermal plant could be supplied with wood waste from landings and along logging roads. The present estimate for the cost of wood-fired thermal power generation is 253 mills/kW·h. The equivalent energy cost of the fuel component is estimated to be 68 mills/kW·h. The fuel cost would increase disproportionately with increasing energy demand because additional fuel would be brought from farther away, but this effect would be partly offset by savings at the powerplant.

The environmental impacts from a wood-fired thermal plant using wood waste would be small because the plant would be small. Some benefit would be derived from more efficient use of the forestry resource.

d. Wood Gasification-Engine Generating Plant at Roquefeuil Bay - The sources of wood waste would be the same as in the case of a wood-fired thermal plant, but wood gasification would require approximately 24 percent more fuel because of the lower overall efficiency of the process. The gross unit energy cost is estimated to be 232 mills/kW·h. A small amount of diesel generation and diesel fuel would be required to supplement the gas-fired generation and the gas derived from wood waste.

The environmental impacts would be similar to those for wood-fired thermal power generation.

e. Coal-Fired Thermal Power Generation at Roquefeuil Bay - The cost of energy from a 1 MW coal-fired thermal plant at Roquefeuil Bay, 6 km from Bamfield, is estimated to be 193 mills/kW·h. It is assumed that coal would be brought by tug and barge from Vancouver (possibly Roberts Bank) at a delivered cost of $61.25/t. Coal-fired thermal power generation could supply any amount of electrical power by increasing the plant capacity as required to meet the load. The availability of fuel would not be a limiting factor.

It has been assumed that diesel generating units would meet 10 percent of the load by providing energy for black starts and peaking. New diesel units would be added as required. New coal-fired units would be added when the capacity factor of the earlier units would reach 75 percent.

The environmental impacts of a coal-fired thermal plant are not expected to be significant because the plant would be designed to meet all government emission standards and because the plant would be small and the total emissions would be correspondingly low. Once-through cooling would be used; the water would be taken from Roquefeuil Bay.

f. Other Resources - Alternative gaseous or liquid fuels would not be suitable for the existing power station because of problems in transportation, storage and/or utilization in the present diesel generating units. There are no known geothermal or peat resources near Bamfield; therefore, these technologies would not be suitable. Wave power and solar power technologies are not sufficiently developed for consideration at Bamfield.

PART B - BELLA BELLA

The peak load (1982/83) and the annual energy for the Shearwater (Bella Bella) diesel generating station was 1.80 MW and 7.74 GW·h respectively. For this report it was assumed that the peak load would continue to grow at 4.5 percent per annum and the energy demand would grow at 3.7 percent per annum. As a result, the projected peak load in 1990/91 would be 2.55 MW and the corresponding annual energy would be 10.35 GW·h. It was also assumed that these growth rates would continue thereafter.

The gross unit energy costs are in March 1984 dollars and assume a 1990/91 load. The estimated costs of energy from the alternative resources near Bella Bella are compared in the following table and they

COMPARATIVE ENERGY COSTS[*1] - BELLA BELLA

	Diesel	Small Hydroelectric		Tidal	Wind	Thermal			Transmission
	Shearwater	Walker Lake	Lakes A, B, C and D	Hochstader Basin	Mount Hand	Wood	Wood-Gas	Coal	Ocean Falls Shearwater
						Norman	Morrison	Bay	
Plant Capacity (MW)	3.6	1.1	0.5	2.0	0.80	2.0	2.62	2.0	14.0
Annual Energy (GW·h)	10.35	7.70	3.50	7.00	2.26	10.35	10.35	10.35	10.35
Project Cost ($/kW)[*2]	516	9159	9640	7218	5885	5123	4157	4704	528
Total Capital Cost ($k)[*3]	1859	11 171	5313	15 915	5132	11 483	12 112	10 415	8141
Fuel Cost (mills/kW·h)	102	-	-	-	-	79	93	29	-
Gross Unit Energy Cost (mills/kW·h)	158	109	111	169	209	211	240	150	100
Payback Period (a)	-	>20	-	>20	-	-	-	>20	10

[*1] At 4 percent net discount rate.

[*2] Includes construction, engineering and contingency costs.

[*3] Includes construction, engineering, overhead and I.D.C. costs.

are examined in detail in Part B, Section 7.0 of this report. The results of this preliminary evaluation of the alternative energy sources potentially available to Bella Bella are as follows:

1. Energy sources which could provide economical alternatives to diesel power generation at Bella Bella (based on gross unit energy cost):

    a. Small Hydroelectric Generation at Walker Lake - A 1.1 MW small hydroelectric generating station on Johnson Channel at the mouth of the creek draining from Walker Lake could provide an estimated 7.7 GW·h/a in 1990/91. This generation assumes some storage in Walker Lake. An overland distribution line 27 km long and 1.5 km of submarine cable would be required between the proposed powerhouse and Shearwater.

        The gross unit energy cost is estimated to be 109 mills/kW·h for a small hydroelectric plant at Walker Lake. The cost would rise to 131 mills/kW·h (1990/91) if the cost of supplementary diesel generation is added. The payback period is estimated to be more than 20 years because of the appreciable supplementary generation (assumed to be diesel) required in the future.

        The environmental impacts resulting from a small hydroelectric development on the creek draining from Walker Lake are expected to be small. Salmon spawn only in the lower 400 m of the creek because they are blocked at that point by a 12 m waterfall.

    b. Small Hydroelectric Generation at Lakes A, B, C and D - A second small hydroelectric site associated with four lakes designated A, B, C and D was identified in a 1963 B.C. Hydro report. The site is on Denny Island, 13 km from Shearwater and could provide sufficient flow for a 0.5 MW plant. It is estimated that 3.5 GW·h/a could be produced from this proposed small hydroelectric plant. The estimate assumes that a small dam could be constructed on the upper part of the Kajusdus Creek in order to divert flow from Lake D into the creek draining from Lake C. If this diversion is not feasible it is estimated that the available energy would be reduced by 15 percent.

        The gross unit energy cost from a small hydroelectric project on Lakes A, B, C and D is estimated to be 111 mills/kW·h. The payback period was not calculated because it would be slightly less economical than Walker Lake and the site was not visited on the trip to Bella Bella; therefore, little is known about the site.

There are significant salmon spawning runs on the Kajusdus Creek which drains from Lake D, but the impact on fisheries resulting from damming a small tributary near the headwaters is unknown. A lesser impact would be the visual effect of the 14 km distribution line to Shearwater.

c. Tidal Power Generation at Hochstader Basin - It is estimated that a 2 MW tidal generating station near the entrance to Hochstader Basin could supply 7 GW·h/a based on a 40 percent annual capacity factor. The gross unit energy cost in 1990/91 is estimated to be 169 mills/kW·h, which is somewhat more than the total cost of diesel generation and considerably more than the cost of diesel fuel. It would be necessary to have a back-up form of reliable generation because tidal power is intermittent and could only be considered as a diesel fuel saver. The addition of supplementary diesel generation increases the estimated cost of energy from tides to 176 mills/kW·h, which is considerably more than the cost of diesel generation.

The environmental impacts of tidal development on Hochstader Basin are expected to be minor. Although there was salmon and herring fishing associated with the basin in the past, these fisheries are believed to be small and they are not presently exploited by local fishermen.

d. Coal-Fired Thermal Power Generation at Norman Morrison Bay - It is assumed that coal could be supplied in essentially unlimited quantities from Ridley Island near Prince Rupert. The delivered cost of coal is estimated to be $61.45/t today and the cost of coal F.O.B. Ridley Island is assumed to rise at 0.5 percent (net of inflation) from 1990/91 onward. The gross unit energy cost from coal-fired thermal power generation at Norman Morrison Bay is estimated to be 150 mills/kW·h in 1990/91.

An allowance has been made for supplementary diesel power generation to provide for peaking and black start capability. This allowance would increase the cost of energy to 161 mills/kW·h. It is assumed that new coal-fired units would be added when the capacity factor of the old units would reach 75 percent and additional diesel generation would be added for peaking. The payback period for coal-fired generation is estimated to be more than 20 years.

The environmental impacts for a coal-fired generating station would be small. Air emissions and solid waste from the plant would be controlled by permits issued under the Waste Management Act.

e. Transmission from Ocean Falls to Shearwater - There is an existing hydroelectric generating station at Ocean Falls. This station was used to provide power for the pulp mill which is closed and the community which is largely abandoned. A

69 kV, 3-phase, wood pole transmission line could be constructed from Ocean Falls to Shearwater. Several potential routes were examined in a study conducted by Reid Crowther and Partners Limited. One of these routes, which includes 52 km of overhead transmission and 1.5 km of submarine transmission, was selected for this report.

This report examines only the cost of energy at Bella Bella and does not imply ownership of any of the facilities from the Shearwater terminus toward Ocean Falls. The gross unit energy cost is estimated to be 100 mills/kW·h (1990/91), which makes it the most economical of any of the alternatives examined for Bella Bella. It is assumed that no diesel back-up would be required, although some diesel generation may be required for security in the early years of operation and perhaps into the future as well. The payback period is estimated to be 10 years.

The environmental impacts of a transmission line from Ocean Falls to Bella Bella arise principally from construction and land alienation. Line crossings may cause some turbidity in creeks during the construction phase. Considerable land would be alienated by the line and forestry values would be affected. In addition, the visual impact of a linear cut through the trees could be significant.

2. Energy sources which would be less economical than diesel power generation at Bella Bella (based on gross unit energy cost):

a. Wind Power Generation at Mount Hand - To date there has been no wind monitoring of high sites near Bella Bella. The existing sites are near sea level and records indicate that the best sites are those accessible to winds off the open ocean. A site on Mount Hand was selected as a potential site

for a wind farm consisting of four 200 kW horizontal axis wind turbines. The annual energy is estimated to be only 2.26 GW·h resulting in a gross unit energy cost which is estimated to be 209 mills/kW·h. Because wind generation could only be regarded as a diesel fuel saver, supplementary diesel generation would be required which would further increase the overall cost of wind generation.

The environmental implications of wind generation result mainly from land alienation and visual impacts.

b. Wood-Fired Thermal Power Generation at Norman Morrison Bay - A wood-fired thermal plant at Norman Morrison Bay on Campbell Island would have to be based on tree farming because of a general lack of wood waste in the area. The cost of wood from tree farms is estimated to be $80.55/ODtonne which is considerably more than the delivered cost of coal (both by weight and by energy content). The estimated gross unit energy cost for a wood-fired thermal plant at Norman Morrison Bay is 211 mills/kW·h.

It is unlikely that there is sufficient, suitable land available on Campbell Island to support a tree farm which could supply the future needs of the generating station. Therefore, supplementary generation would be required to provide for future demands as well as black start capability. It is assumed that wood-fired generation could pick up the expanded demand until the year 2006. At that time new generation would be diesel-powered or from another alternative. On this basis and assuming supplementary diesel generation, the gross unit energy cost in 1990/91 is estimated to be 224 mills/kW·h.

The principal environmental impact would be land alienation resulting from tree farming operations. Approximately 3600 ha of dedicated land would be required for a sustained yield to supply a 3 MW plant. An additional environmental impact would be the increased turbidity in lakes and creeks which could result from tree farming operations.

c. Wood Gasification-Engine Generating Plant at Norman Morrison Bay - A wood gasification-engine generating plant at Norman Morrison Bay could supply approximately 2.6 MW of electrical power. The plant size is limited by the space available for tree farming. The gross unit energy cost is estimated to be 240 mills/kW·h, which is the least economical of the alternatives examined for Bella Bella. The cost of supplementary diesel generation for serving the load in 1990/91 and the cost of additional diesel generation to serve future loads tends to make wood gasification an even more expensive alternative.

The environmental impacts from wood gasification-engine generation would be similar to those for wood-fired thermal generation.

d. Other Resources - The problems with utilizing alternative fuels in the existing diesel plant, geothermal power, peat-fired thermal power, wave power and solar power are similar to using these technologies at Bamfield. Comments provided in the discussion of these alternatives would apply to Bella Bella as well.

RECOMMENDATIONS

The following recommendations are made on the basis of this preliminary evaluation:

1. B.C. Hydro could continue to supply electrical power to Bamfield and the surrounding communities by using diesel generation, but the cost would continue to be high. It is recommended that B.C. Hydro proceed with the plan to integrate Bamfield into the grid by constructing a 25 kV, 3-phase distribution line from Port Alberni. This alternative would certainly be economical before the base year 1990/91 which was selected for this report. Small hydroelectric development would provide an alternative for local generation, but it is less economical than integration and should only be examined further if the distribution line should become overloaded at some time in the future.

2. Similarly, B.C. Hydro could continue to supply electrical power to Bella Bella and the surrounding communities by using diesel generation, but the cost would continue to be high. It is recommended that B.C. Hydro continue to examine the feasibility of supplying electrical power to Bella Bella by means of a 69 kV, 3-phase transmission line from Ocean Falls. This alternative would be the most economical in the base year 1990/91. If this alternative should prove infeasible, the methods of local generation which should be investigated are coal-fired thermal and small hydroelectric power generation. For the latter alternatives the following investigations would be required:

   a. Coal-Fired Thermal Power Generation - Investigate the feasibility of a thermal steam plant using coal supplied from Ridley Island. Examine the cost of coal from the Telkwa and Peace River coalfields. Conduct site selection studies paying particular attention to such details as water supply for boiler feed and condenser cooling, dock facilities for coal barges, ash disposal area, road access etc. Determine the site specific environmental impacts of a small coal-fired thermal plant. Investigate in detail the cost and availability of packaged thermal generating plants and determine

      accurate transportation and construction costs. Conduct a simulation to determine the impact of future load growth projections on plant economics.

   b. Small Hydroelectric Power Generation - Investigate the feasibility of small hydroelectric power generation at Walker Lake and Lakes A, B, C and D. Conduct an investigation of the impacts on the salmon fishery resulting from the development of Walker Lake and the potential diversion of Lake D. Conduct site investigations at both sites. Develop project layouts including all of the facilities to connect them to the existing power system. Prepare sufficiently reliable cost estimates to permit an investment decision. Specifically the following work should be undertaken:

- develop regional hydrology data to provide simulations of monthly flows at each site,
- collect information on the potential for lake storage,
- determine essential topography by barometric levelling,
- inspect potential intake sites, penstock routes, powerhouse locations and transmission line routes,
- provide preliminary layouts and an estimate of capital costs,
- prepare a report for selecting the best site, and
- install a gauging station at the most promising site and conduct streamflow studies.

REVIEW OF ALTERNATIVE ENERGY SOURCES AND ELECTRIC POWER

UTILITY PROPOSALS FOR CASSIAR, B.C.

SUMMARY

Introduction

This report describes the electrical energy supply options for the community of Cassiar which is located in northwestern British Columbia. The major activity at Cassiar is the asbestos mine and mill owned and operated by Brinco Mining Limited. Brinco employs approximately 410 persons out of the total community population of 1400. Besides the Cassiar asbestos activities, there are two small producing gold mines and a Ministry of Highways maintenance facility located in the immediate vicinity.

The townsite also forms a regional centre with police, education and hospital facilities established there.

The supply of electrical energy to the mine, mill and townsite has been a significant cost factor for Brinco. The company operates an all diesel power plant which has an annual diesel fuel requirement of approximately 17 million litres costing approximately $6 million per year. Since the late seventies, Brinco have sought to reduce their energy costs by investigating alternative sources of supply and by instituting an aggressive energy conservation program.

This report describes three aspects of energy supply for the Cassiar region. Firstly, the current energy supply situation is described and projections of electrical energy production by continued use of diesel plant are made. Secondly, alternative energy sources are reviewed and the most promising available hydroelectric sites are examined. Hydro-site development costs are updated and a benefit-cost analysis is described for two hydroelectric development options. Thirdly, the concept of a regional utility is examined. Corporate structure and financing alternatives are described, and utility cash flows based on the development of hydroelectric sites are given. The effects of Government regulatory requirements on a utility scaled to meet regional requirements are discussed.

Energy Supply Alternatives

At present the annual energy requirements of the Cassiar region are met by importation of diesel fuel and propane as shown below:

	Amount (litres)	$	% Total Cost
Diesel fuel - power generation	17 000 000	6 500 000	57%
Fuel - heating	12 000 000	4 600 000	40%
Propane - heating	420 000	300 000	3%
		11 400 000	100%

The diesel powerplant installed capacity at Cassiar is 12 MW and at other mines and facilities is 3 MW. Combined regional electrical energy demand is 59 million kW.h/year.

Past and present investigations into reducing energy costs have enabled the following conclusions to be drawn.

i) It is unlikely that the B.C. Hydro grid will be extended to Cassiar until the Iskut/Stikine system is developed (at least 15 years in the future) or until the development of other major mines leads to substantially increased regional demand.

ii) Wood waste, natural gas, nuclear and coal fired thermal do not appear to be viable alternate energy sources at present.

iii) Several hydroelectric sites in the vicinity of Cassiar have been investigated, the most promising of which are located on the Cottonwood River approximately 40 km southwest of the town of Cassiar. Two development alternatives, one of 7.5 MW capacity costing $39.9 million, and the other of 12 MW capacity costing $61.5 million were studied for this report. The 7.5 MW project can supply approximately 88% of the regional electrical demand whereas the 12 MW project can supply approximately 96% of the regional electrical demand. Under current day economic conditions the 7.5 MW project can supply energy in the short term at approximately the same unit cost as energy generated by diesel plant. In the long term, hydroelectric unit energy costs will be significantly less than diesel generation unit costs.

iv) It is unlikely that hydroelectric energy will displace fuel oil for heating purposes. The current energy conservation program being run by Brinco should therefore be continued in order to minimize heating fuel costs.

v) Social benefit-cost analysis of the hydroelectric alternatives, conducted from the viewpoint of Canadian social interests, indicates internal rates of return of 17% for the 7.5 MW project and 8% for the 12 MW project. From the national viewpoint 7.5 MW project appears viable on the basis of petroleum fuel substitution alone.

vi) Hydroelectric development of the Cottonwood River is unlikely to cause significant wildlife and fisheries damage. If access to recreation facilities is taken into account, the net environmental impact will be considered positive by a large percentage of local inhabitants.

Regional Utility Alternatives

Alternative organizational structures for a regional utility can have differential tax and financing implications which could prove significant in initiating a project of this type. The conventional utility structure may be less attractive in terms of the level of equity financing required by the proponent and the potential absence of certain tax write-offs (e.g. investment tax credit). On the other hand, the conventional structure could be more successful in attracting new customers, in obtaining suitable financing and in dealing with government and regulatory officials on tax and policy matters.

The financial analysis of the existing diesel and small hydro options, assuming a conventional utility structure, indicates that the 7.5 MW project is preferable under a base case which assumes existing tax law and Class 34 CCA's. The relative advantage of the 7.5 MW project under the base case erodes without the Class 34 CCA's. On the other hand, the relative advantage of 7.5 MW project under the base case improves markedly with assumed reductions in taxes (property taxes, water licence fees) and the utility's cost of capital.

The review of regulatory implications of a regional small hydro utility indicates the requirement for a long term commitment to service regardless of the organizational structure. The utility's exemption status from regulation requires evidence that the small hydro project is economically efficient, ensures continuity of service (particularly to third parties), applies non-discriminatory prices, is financially feasible, and is environmentally acceptable. These requirements certainly imply a social responsibility for providing continuous service over the long term. Private sector proponents should recognize the limits placed on their flexibility in terms of curtailing or eliminating service in the event that it became privately (rather than socially) desirable to do so.

SMALL HYDRO FEASIBILITY
FOR ESPERANZA, B.C.

EXECUTIVE SUMMARY

The Nootka Mission Association (NMA) is the registered, non-profit society which administers the community of Esperanza. This remote settlement of about 42 permanent residents is located on the northwest coast of Vancouver Island.

This study is directed primarily to the board of NMA and an effort has been made to present the material clearly and in a manner that can be understood by a non-technical individual. This is particularly important when a significant amount of self-development is anticipated, as is the case here.

Esperanza relies on a 50 Kw diesel plant to produce all of its electricity. Fuel costs are the single largest operating expense. This was reported as $29,117. in 1982.

The objective of this study in its broadest terms is to identify and assess the various options available to reduce the energy consumption of the community and, particularly, to reduce the use of oil. After a preliminary site investigation it was apparent that small hydro and energy conservation clearly represented the most attractive alternatives.

A detailed community survey was conducted of the electrical loads, building construction, usage patterns, level of energy management and types of fuels used. The results indicated substantial energy savings could be achieved in several areas. The most significant of these were hot water tank insulation, home insulation (CHIP funding available), propane conversion for heating domestic hot water and clothes dryers. Several of these demonstrated a simple return on investment of about one year.

Lutes Creek and Cover Creek were identified as offering a significant opportunity for small hydro development. The steps for assessment included 1) stream gaging to develop an adequate hydrological model, 2) site survey to determine the site development plan, 3) survey of existing and anticipated loads, 4) preliminary engineering to develop costs and 5) financial analysis. Each of these steps was conducted for both Lutes and Cover Creek.

The most attractive scale for development of Lutes small hydro was 100 kw peak (both streams are seasonal and power output will vary) at a capital requirement of $198,035. This assumes Esperanza provides most of the labour. The financial

analysis demonstrated that the average cost of power (in 1984 dollars), over the 24 year project life, would range from 2.3 to 4.2 cents per Kw-hr. This compares favourably to 19.4 cents per Kw-hr for the existing 50 kw diesel system assessed over the equivalent life.

The most attractive scale for development of Cover Creek was 65 Kw peak. The hydrological study determined that this site would not develop significant power for 50% of the year due to low stream flows in the dryer months from its small watershed. The capital requirement was estimated at $77,562. and the cost per Kw-hr over the 24 year project life was 9.7 to 11.0 cents per Kw-hr. This was higher than Lutes because of the need for large amounts of supplementary diesel power.

It was recommended that the Nootka Mission Association commence immediately to pursue the various options for raising the funds to develop the proposed Lutes Creek small hydro site. If, after two years, the financing for Lutes is still incomplete Cover Creek should be carefully considered for development together with an aggressive program to cut peak power requirements.

FEASIBILITY OF [illegible]
TO MOSES INLET, B.C. FORESTRY CAMP UNDER CONTRACT

SUMMARY

The Moses Inlet Camp is a modern, 70 man logging camp located on the central coast of British Columbia operated by Crown Forest Industries Ltd. It presently depends on a diesel generating plant for power, comprising 2 - 100 kW units, and because it has electric water and space heat the potential use of fuel is high. The camp is located near a potential hydro power site, and this report evaluates the feasibility of developing that site.

There is nothing unusual about the situation at Moses Inlet, because it occurs frequently on the coast of British Columbia. What is unique is the approach that an outside investor would develop the hydro power site and sell power or generating capacity back to the logging camp. This approach requires a more careful analysis of the camp loads, local hydrology and operating characteristics to ensure that a project is sized to make the project sufficiently attractive to the investor. This must occur without sacrificing the operational convenience of the camp.

In this report, the camp loads have been analysed based on the known electric devices installed and the projected occupancy of the camp. The logging camp operates on a repetitive daily pattern, hence the loads are defined in increments representing sleeping hours, breakfast, work day, cleanup/dinner, evening/laundry and late evening. The loads are calculated for an unregulated case (no energy management) and a regulated case, where energy management is used to avoid the peak loads (especially on water heat) by gradual heating and storing energy throughout the day.

The local hydrology is based on regional records as there are no streamflow or rainfall records at Moses Inlet. However the rainfall pattern in this area of the coast is relatively consistent (and heavy). The subsequent analysis accounts for the long term expected flow variations on a monthly basis.

The operating characteristics of a potential diesel/small hydro system have been considered in the study. Important considerations are situations when flow is limiting or when installed capacity of the hydro power plant is limiting. During these situations the diesel generation plant must be utilized and in order to properly operate the diesel plant some additional load may have to be relinquished to the diesel by the hydro power plant.

The project is designed as a relatively simple intake/penstock/powerhouse system with a short transmission line to the camp. Several component sizes were costed to establish a range of costs for different installed capacities.

The optimal plant size was evaluated over a broad range, then load options were applied over a narrow range. This has been done by establishing a base case of 20 different plant sizes to determine the range of least cost options (based on cost per kilowatt hour). These were subsequently tested with other design variables to ensure that the lowest cost option was still valid. The apparent optimal size plant is 90 kW with a fully occupied camp, but the cost of other plants from 75 - 100 kW varies over a narrow range (0.25¢/kW.h) so that other considerations (eg. convenience or a special price on a particular component size) may result in the selection of a different installed capacity within the determined range. Smaller camp sizes favour a lower installed capacity, with 75 kW being the lower limit.

The final task of the study was to provide a financial analysis to guide the investment decisions, and enable an equitable Power Sales Contract to be evolved between Lancaster and Crown Forest. The financial analysis considers such features as: the expected life and staging of the logging camp; the likely long term work force of 40 men based on detailed discussions with Crown Forest; the effects of energy management; and technical requirements for load sharing between the hydro/diesel system. The installed capacity was determined to be in the range of 75 kW to 90 kW with a gross head of 105 metres, subject to final negotiations, which will provide electrical energy needs of 70% to 73% of the total camp requirements at a price which is less than the cost of diesel-generation. The existing diesel generation plant comprising 2 - 100 kW units will still be required to provide standby and peaking capacity, but the planned purchase of an additional 100 kW unit will not be required.

EVALUATION OF ELECTRICAL SUPPLY ALTERNATIVES FOR SEYMOUR ARM, B.C.

SUMMARY

Stage 1

The community of Seymour Arm lies at the northern end of Shuswap Lake in British Columbia. It consists of a mixture of summer cabins, permanent residences, farms and commercial establishments, all of which rely on independent power generation systems. Permanent residents pay an average of over $1000 per year for an electricity supply that falls short of provincial normals. Over 200,000 litres of diesel fuel and over 65,000 litres of propane are used annually to provide the service that is provided by hydro generated electricity in most areas of the province.

The community is making an effort to secure an adequate and economical power supply which reduces the amount of oil used, an objective which is consistent with that of the Remote Community Demonstration Program. The purpose of this Stage 1 study is to determine the most attractive power supply option, either a grid connection, a hydro power system, or a diesel generation system. The alternative systems are examined in terms of their capital costs and long term operating costs.

This report concludes that the most attractive system is the grid connection, based on its flexibility to expand, its lower present value cost and its ease of maintenance. The grid connection provides good opportunities for the community to participate in some aspects of the construction, and thus reduce overall costs.

The grid connection is attractive from the viewpoint of overall system costs, but it is still relatively expensive, because the small community must absorb much of the installation cost, despite a generous allocation from BC Hydro through a Rural Electrification Assistance grant. One of the major difficulties in developing a power supply scheme is to equitably divide the community's share of capital cost amongst the property owners. A cost sharing scheme is proposed in this report but further interaction with the community will be required to assure an acceptable formula. Subsequently, in Stage 2 of the study, an economic and financial evaluation was made, which analysed the costs of the power supply options from the national and local perspectives and which provided insight into the mechanisms available to enable a community power supply system to be implemented.

SUMMARY

Stage 2

The community of Seymour Arm, which has co-sponsored this Stage 2 Economic and Financial Evaluation of electrical supply alternatives, has continued to work towards establishing a community power supply while this study was in preparation. Based on the results of the Stage 1 study, which favoured a grid connection, meetings have been held with all concerned parties to establish an implementation plan.

This Stage 2 study examines the economic and financial aspects of all the options considered (grid connection, hydro power plant, diesel generating station) and tests each for sensitivity by varying parameters. The economic analysis examines the power supply options in terms of economic resources only, and as such the national viewpoint is expressed. Land, labour, equipment, material, diesel fuel and hydro electricity are all evaluated in terms of their social opportunity costs or their most valuable use in another application. The grid connection alternative is judged by a wide margin to be the least cost option from the national perspective.

The financial analysis re-examines the costs of the three alternatives from the viewpoint of the property owner at Seymour Arm. Full account of all taxes, grants, subsidies and actual at-site costs is taken into consideration as well as the effect of inflation. The main differences in the accounting method for the financial analyses when compared with the economic analyses are in the ways diesel oil prices and electricity prices are treated together with the effect of subsidies. The financial evaluation also leads to a clear recommendation of the grid connection as the least costly choice for the residents of Seymour Arm.

The choice facing the property owners of Seymour Arm is whether they are prepared to pay the residual cost of the grid connection based on a tax increase which is proportional to property assessments. This method is considered the fairest as it is simple to administrate and makes a reasonable assumption that a property owner's house and improvements will benefit more from the grid connection if the house is more valuable to begin with. Owners of vacant lots also receive a benefit as property values are enhanced and the possibility of a future, convenient power connection readily exists.

If the residents choose in favour of the grid connection in a referendum to be held in May 1984, much work still remains as the details of the project will require considerable organization and management to carry it through to a successful completion. *

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* The Columbia Shuswap Regional District held a referendum in summer 1984, asking Seymour Arm residents if they were willing to pay increased taxes to cover the cost of a transmission line from the provincial power grid. The community voted against the motion.

EXECUTIVE SUMMARY

PREFEASIBILITY STUDY OF
HYDROELECTRIC POWER GENERATION
AT VERMILION FALLS, ALTA

The Project

The Vermilion Chutes on the Peace River comprise a series of rapids with a total fall of approximately 3 m and Vermilion Falls which is located approximately one kilometer downstream. The study investigates the feasibility of developing a source of hydroelectric power at Vermilion Falls. The power generated would supply the nearby communities of Fox Lake and John D'Or Prairie. It would provide an alternative to the current dependency on diesel generation at both communities with its comparatively high operating costs and with the attendant uncertainty of escalating fuel prices.

The peak demands at Fox Lake and John D'Or Prairie were both estimated to be 215 kW in 1985. The loads are estimated to increase at an annual rate of just under 5 percent for the period of the study.

The most favorable site is located midway between the two communities. Approximately 4.5 m of head is available at the falls except when they are flooded during the winter due to river ice jamming downstream. It has been estimated that the head across the falls would be too little for turbine operation for about four months each winter. The existing diesel generators would be retained and operated during this period. The benefits of the hydroelectric development at this site are expressed by a reduction in the quantity of fuel required.

The Preliminary Design

A preliminary design has been proposed for a development on a rock ledge at the north and left side of the river adjacent to the falls. This location was chosen during a site reconnaisance visit.

The project envisaged would comprise an upstream rockfill groyne to divert 30 m^3/s of the river flows into a deepened approach channel leading to a power canal excavated through the rock ledge. The water would then pass through one or two horizontal axis Kaplan turbines and be discharged downstream of the falls via an excavated tailrace channel.

The rock excavated from the canal, powerhouse and tailrace would be used to construct the river diversion groyne and extend it to protect the powerhouse from impacting ice thrusts. The turbines would be set below the current rock surface elevation. The reinforced concrete powerhouse structure would be constructed as a open well to an elevation above the anticipated maximum ice level. From observations of ice scour of the left river bank, it is estimated that the top of the powerhouse substructure would have to be built 8 m above the existing rock surface.

During the eight months that the full 4.5 m head would be available, the powerplant could continuously supply 500 kW of electric power from each turbine. This power would be carried by new transmission lines to each community.

Estimated Costs

It is estimated that the project, including access roads and transmission lines, would cost approximately $6,400,000 and $8,700,000 for 500 kW and 1000 kW installations respectively serving both communities and approximately $6,000,000 for 500 kW serving only John D'Or Priarie. Access to the power site for construction and for operation and maintenance of the powerplant would represent a major capital cost component.

Economic Viability

The economic evaluation of the proposed project has been based upon the value of fuel replaced over 30 years. The requirement for supplementary power production during winter months makes it necessary to maintain the existing diesel power plants.

The base case considered was a 1000 kW installation serving both communities. This would result in savings in fuel oil consumption which are predicted to increase from 300 000 litres in the first year of operation to 1 000 000 litres in the 30th year. The value of the fuel saved over a 30 year period was compared with the estimated hydroelectric costs. This hydroelectric installation would be more expensive than continued diesel operation by more than 7 million dollars in present worth terms.

The sensitivity of this result to variations in the basic assumptions was tested. In all the sensitivity tests, including consideration of 12 month hydro operation, variation in discount rates, inflation rates, escalation in fuel prices, and plant capacity, the hydroelectric installation remained uneconomic. Even with the favourable assumptions, the hydroelectric development cost approximately $4 million more than diesel generation.

CONCLUSIONS

A hydroelectric development at Vermilion Falls to provide electric power to the communities of John D'Or Prairie and Fox Lake is technically feasible but the project would not eliminate the need for diesel generation and would not achieve sufficient fuel savings to be economically attractive.

RECOMMENDATIONS

It is considered that further study of the proposed small scale hydroelectric development potential at the Vermilion Falls site is not warranted.

SMALL HYDRO PREFEASIBILITY STUDY FOR WHITESAND CONTROL DAM

NEAR SOUTHEND, SASK.

EXECUTIVE SUMMARY

The main aspects of this study can be summarized as follows:

1. The community of Southend is typical of many northern isolated communities. Basic services such as power, health facilities and police are provided. The economic base of the community consists of hunting, fishing, trapping and tourism. Apart from the continuing construction of new facilities within the community, the only proposed economic development in the geographic area that would have provided the community with both employment and commercial prospects is a graphite mine at Deep Bay. This mine has been shelved at this time due to a soft market and will probably not be reconsidered until the mid-1990's. Factors that could affect this decision would be an increase in demand for graphite and/or a reduction in the cost of electricity and hence the cost of production.

   A proposed gold mine at Waddy Lake is unlikely to have any effect on the community of Southend. This mine, which will probably be commissioned in 1986, could however, be provided with electricity from a hydro-electric development at Whitesand Dam.

2. Three load forecasts have been prepared for Southend for the period 1984 to 1995. The first load forecast considers only the normal electric load and represents the lower limit to the load growth. The second considers the normal electric load and the increase in load caused by a total conversion from heating oil, propane and wood to an equivalent consumption of electricity: this represents the upper limit to the load growth. The third represents the most probable load growth and considers the normal electric load together with the increase in load due to the conversion of oil and oil/wood furnaces to a hybrid heating system.

   The third or most probable case results in projected energy requirements and peak load (at the generator) for the communities of Southend and Brabant Lake of 6,233 MWhr and 2,257 kW respectively by 1995. These projections exclude any mining development. The projected energy requirements and peak load are 4,000 MWhr and 750 kW for the proposed gold mine in the Star Lake/Waddy Lake area.

Due to the absence of information regarding the proposed graphite mine at Deep Bay, it was not possible to assess its impact on the community of Southend. However, if the mine proceeds, it will have a peak load of about 3,000 kW. This load will be served by a separate additional development to be constructed some time after the initial installation.

We understand that the existing diesel generating station is in need of a major upgrading and it has therefore been assumed that the proposed hydro-electric installation would be commissioned as quickly as possible to replace the existing plant. The load forecast indicates that a 750 kW unit would meet the requirements of the communities of Southend and Brabant Lake for two years at which time another 750 kW unit will become necessary. Further, the load growth indicates that a third unit will be required before 1995. This unit has not been included in the economic analysis because its date of commissioning is highly dependent on the rate of acceptance of the hybrid heating system.

A 750 kW unit will be required to serve the proposed gold mine in the Star Lake/Waddy Lake area. The current schedule for the mine indicates that this unit should be part of the initial installation.

Cost estimates were therefore prepared for an initial installation consisting of either a single 750 kW unit or two 750 kW units, as well as for a separate later 3 X 1000 kW development to serve the proposed graphite mine.

3. Layouts for the proposed initial 2 X 750 MW hydro-electric development have been prepared and are presented as Figures 4.6 and 4.7. This development is located on the centre island between the two dam sluiceways. This location could ultimately accommodate up to four 750 kW units. The proposed 3 X 1000 kW power plant to supply power to the mine at Deep Bay is a separate installation as shown on Figures 4.8 and 4.9. This development would be built at some future date after the commissioning of the initial installation. Both arrangements have been designed to maximize off-site fabrication and minimize site construction. They comprise a syphon intake, steel penstock and powerhouse. The powerhouses have steel framed substructures.

The net minimum head available at this site is approximately 6.8 m. The turbine discharge capacity at this head is approximately 26 cms for the initial 2 x 750 MW installation and 52 cms for the 3 x 1000 kW addition.

The most economical turbine, of those considered, is the Turbogen semi-Kaplan turbine by Waterwheel Erectors. This turbine would also be the easiest to salvage should this become necessary. Layouts for powerhouses using this turbine are presented as Figures 4.4 and 4.5. The proposed schedule presented on Figure 5.1 is also based on this turbine. Because the delivery-lead time for this unit is considerably shorter than for the Kaplan and Ossberger turbines also considered, the initial development could be commissioned in mid-1986.

4. The only alternative hydro-electric site considered for evaluation was Otter Rapids on the Churchill River. A development at this site would require the construction of a dam. The cost of a hydro-electric development at this site is estimated to be $18,970,000 for an initial 2 X 750 kW installation and $10,020,000 for the addition of 3 X 1000 kW at a later date. The costs are in 1984 dollars and in accordance with the terms of reference do not include the cost of transmission lines.

An initial 2 X 750 kW development at Whitesand Dam is estimated to cost $7,560,000 and a separate 3 X 1000 kW development to be constructed later is estimated to cost $10,920,000. These costs are in 1984 dollars and assume the materials and equipment will be transported to site over a winter road to be constructed between Southend and Whitesand Dam. The cost of clearing and constructing the winter road is included in the capital cost of the initial installation only. It is assumed that the road would be maintained and available for use should the 3 X 1000 kW addition be built. On the basis of capital cost, this site is the most economical. The cost of a single 750 kW unit at this site is estimated to be $5,440,000; this installation is assumed to have an intake and penstock sized for two units.

For the initial 2 X 750 kW development with one unit serving the communities of Brabant Lake and Southend and one serving the proposed gold mine in the Star Lake/Waddy Lake area, the unit cost of supplying energy is estimated to be 13.4 cents per kWhr at an assumed effective discount rate of 6%. This value is in 1984 dollars and is based on a 35 year life for the development. It includes the installation of a second 750 kW unit two years after the initial development has been commissioned. Annual operating and maintenance costs have been included. The weighted average cost of supplying electrical energy and heat by diesel units and oil heaters is estimated to be 17.1 cents per kWhr in 1984 dollars.

For a later separate 3 X 1000 kW development fully dedicated to supply the proposed graphite mine at Deep Bay, the unit cost is estimated to be 6.7 cents per kWhr at an assumed effective discount rate of 6%. This value is in 1984 dollars and is based on a 35 year life of the plant. Annual operating and maintenance costs have been included. Based on the existing diesel units at Southend, the cost of supplying energy by diesel generators is estimated to be 19.1 cents per kWhr in 1984 dollars.

5. RECOMMENDATIONS

Based on the findings of this study, we recommend that discussions be undertaken with the Saskatchewan Minerals Development Corporation to determine the impact of the unit cost of supplying power from Whitesand Dam on the proposed mines at Waddy Lake and Deep Bay.

We also recommend that, on the basis of unit costs, this project should proceed. A decision should be made very early in 1985 to enable the initial generating facilities to be on-line by mid-1986. This schedule would allow the gold mine at Waddy Lake to be served by the new hydro-electric development.

EXECUTIVE SUMMARY

1. Background

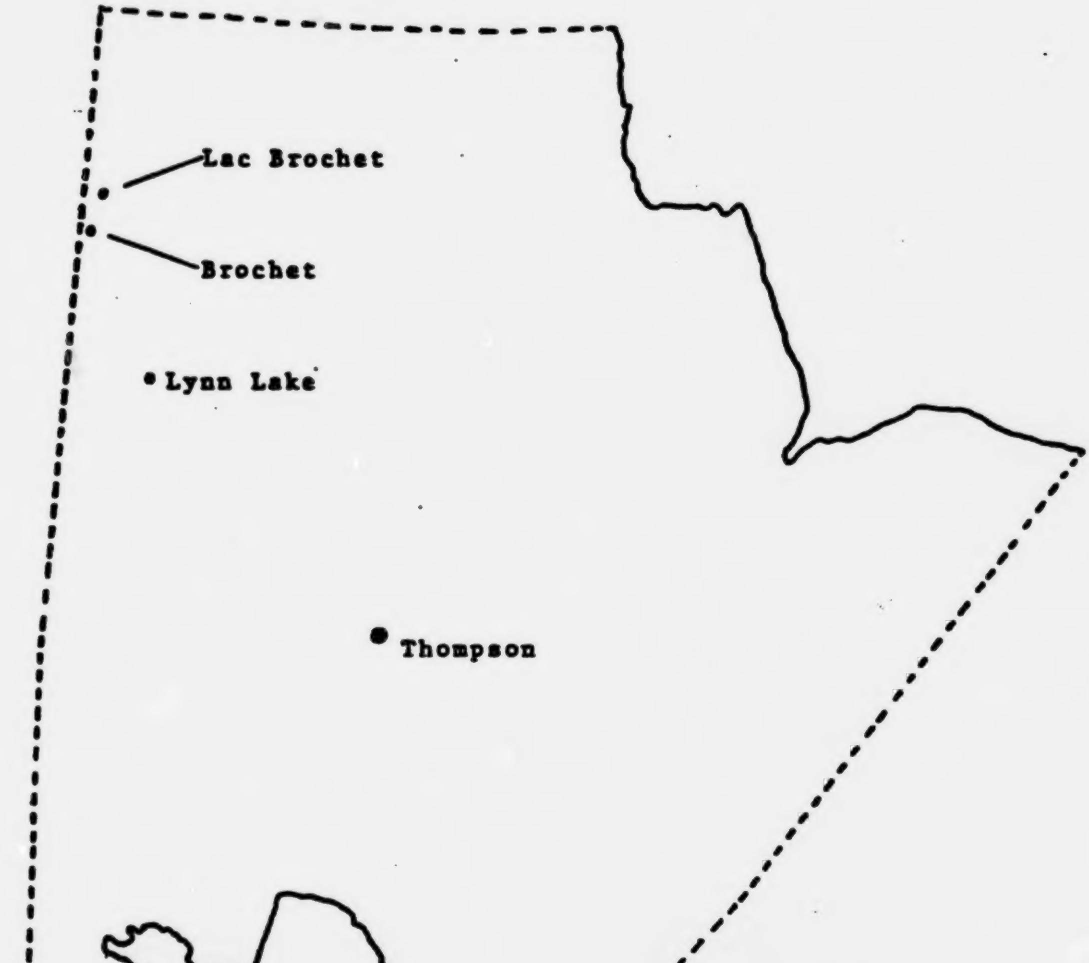
The communities of Brochet and Lac Brochet are situated in the extreme northwest region of Manitoba (see maps ES-1 and ES-2). The communities are 125 kilometers (72 miles) north of the closest Manitoba Hydro grid service system at Lynn Lake.

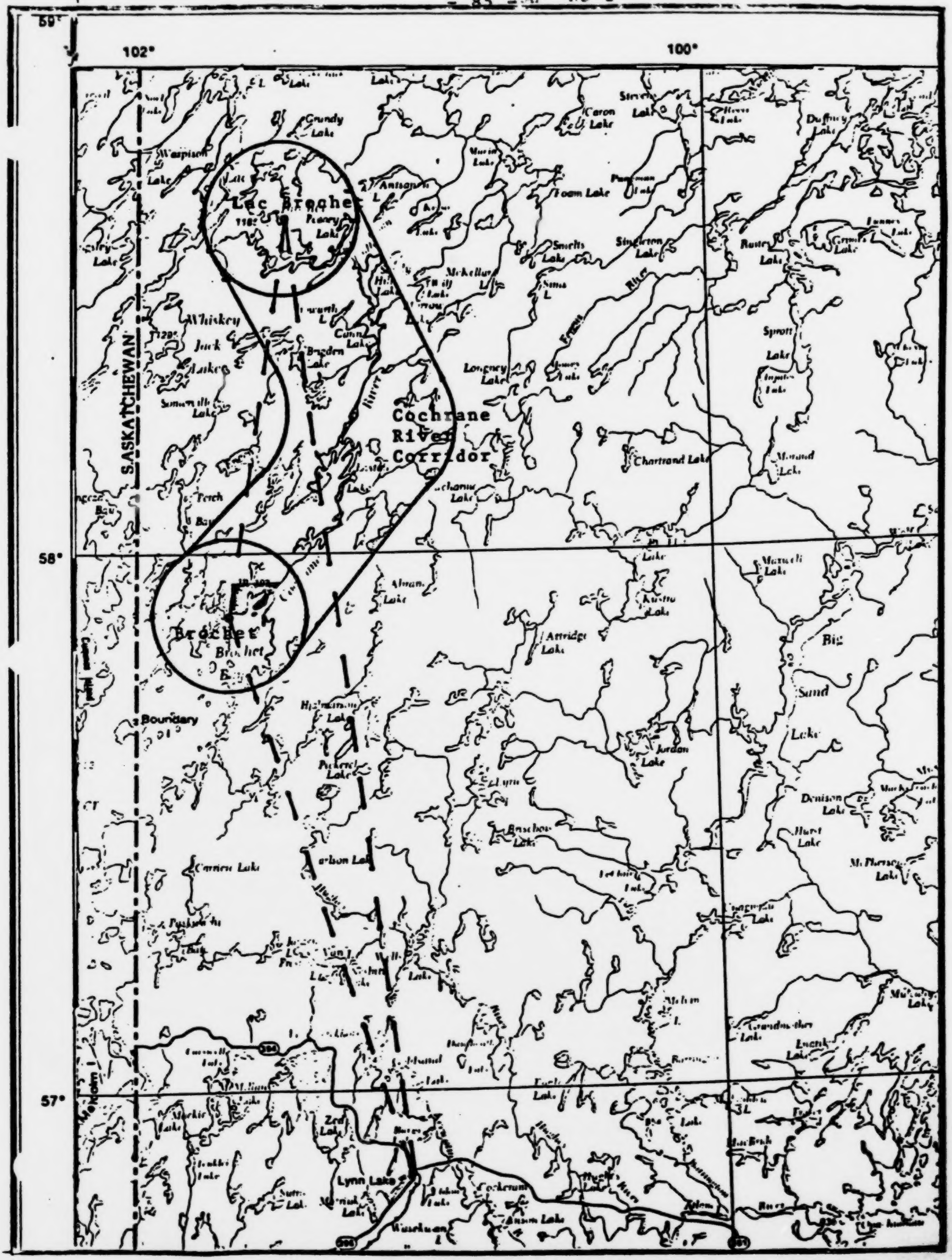
This energy alternatives study was initiated by the communities of Brochet and Lac Brochet out of concern for finite wood fuel resources and the ever increasing cost of fuel oil, gasoline and other fossil fuels. Diesel generators provide limited 15 amp. service to residential customers. The communities rely upon wood for residential heat and cooking. Diesel fuel, fuel oil and gasoline are transported to the communities via air transport or winter road.

The study area presently contains 972 individuals including Treaty Indians and Metis. These community members reside in 136 homes with an average occupancy of 5.8 - 6.0 per household. Non-Natives reside in the area as a result of professional employment opportunities. Study area economies are generally depressed with few employment opportunities available. Present economics are predominantly traditional including hunting, fishing, trapping and firewood gathering.

Based on the extrapolation of past growth trends, the study area population may triple to 2,590 individuals over the next 25 years. Housing stock may increase to 416 units as per current housing allocations. This increased population would require enhanced social support, community and economic development.

Map ES-1


Lac Brochet
Brochet
Lynn Lake
Thompson
Winnipeg


59°
102°
100°
58°
57°
Lac Broche
Brochet
Cochrane River Corridor
SASKATCHEWAN
Boundary
Whiskey Jack Lakes
Grundy Lake
Peterry Lake
Brochet
Chartrand Lake
Big Sand Lake
Attridge Lake
Jurdon Lake
Denison Lake
Hurst Lake
Sprott Lake
Foam Lake
Caron Lake
Carriere Lake
Zed Lake
Lynn Lake
Laurie River

GEOGRAPHIC LOCATION: BROCHET-LAC BROCHET

2. Present Energy Supply

Available data from current energy suppliers was examined to determine present energy consumption and costs. A survey of local community members was also undertaken to expand the data base. Present energy consumption has been estimated as follows:

Present Energy Consumption	1982/83
Brochet:	
Diesel (kw/mWh)	210/886
Oil (L)	303,464
Wood (cords)	1,009
Gasoline (L)	65,156
Propane (kg)	2,190
Lac Brochet:	
Diesel (kw/kWh)	66/284
Oil (L)	76,930
Wood (cords)	535
Gasoline (L)	43,245

Present energy costs experienced in the study area are estimated as per the following table ES-1.

The costs of diesel operations, oil, gasoline and propane consumption were obtained directly from suppliers. Cord wood utilization, along with the gasoline required to power the machines (boats and skidoos) used to obtain the wood, was estimated in view of survey responses and local conditions.

TOTAL ENERGY COSTS (1982/83) BOTH COMMUNITIES

Table ES-1

	Electricity 82/83 ($)	Gasoline/ Wood 82/83 ($)	Oil 82/83 ($)	Propane 82/83 ($)	Total Estimated Cost ($)
Brochet					
Treaty	$ 28,800	$ 61,950	$ 2,378	$-0-	$ 93,128
Metis	13,100	25,800	-0-	-0-	38,900
Non-Native	147,140	-0-	135,646	$2,434	285,220
Lac Brochet					
Treaty	11,180	89,100	32,500	3,900	136,680
Non-Native	143,655	-0-	19,468	3,546	166,669
TOTALS	$343,875	$176,850	$189,992	$9,880	$720,597

Average cost per KWh for each source in 82/83 was:

Electricity	25.7¢/kWh equivalent (B) 57¢/kWh (LB) Full Cost Diesel
Firewood	3.5¢/kWh equivalent ($115/cord @ 65% efficiency)
Oil	7.2¢/kWh equivalent (42.3¢/L - 83¢/L @ 60% efficiency)

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Trees in the study area are predominatly Black Spruce and are being utilized for residential heating and cooking. Due to unfavourable growing conditions, trees are usually smaller and require 200 years rotation age (maturity). Fires have burned roughly half of the land area. The annual rate of burn over the past 33 years has averaged 1.5%, amounting to 46 km^2 (18 square miles) or roughly half a township per year.

Wood consumption per home is difficult to estimate and a range of 11 - 18 cords per annum has been discussed in this report. At 18 cords per annum, approximately 100,500 cords of fuel wood will be harvested over the next 25 years. Present fuel wood reserves have been estimated at 859,300 cords.

There appears to be no imminent threat of wood resource depletion. However, access distance will increase over the planning period while additional fires may severely reduce available resources.

3. Energy Conservation Potential

Significant energy conservation potential exists in the study area. Field investigation has yielded the following cost saving estimates:

Summary of Energy Conservation Potential ($1984)

	Projected Savings ($/Year)	Estimated Cost ($)	Simple Payback (years)
Air Leakage Reduction	$79,600	$125,000	1.6
Insulation	3,500	9,000	2.6
Lighting Conversion	7,000	6,000	.85
Temperature Setback	6,000	1,000	.17
Oil Furnace Efficiency	20,000	12,000	.6
Total	$98,100	$153,000	

Air leakage reduction includes weatherstripping of doors/windows and caulking of all cracks in exterior walls of all houses and buildings in the study area, excluding the school and teacherages in Brochet.

Insulation is required along the basement walls of the church and priest's house in Brochet.

Lighting conversion includes replacing all regular fluorescent lamps and ballasts with low wattage types for classrooms in Lac Brochet and the nursing stations, grocery stores, etc. in both communities.

Temperature setback involves replacing existing thermostats with setback types for classrooms in Lac Brochet.

Oil furnace efficiency improvement includes the installation of flame retention head burners, reducing nozzle size and adjusting for thermostat settings for schools and nursing stations in both communities.

4. Energy Demand Forecasts

Three electrical load alternatives were considered in this analysis:

1) Low Load Forecast - the present 15 A, 240 V service capacity limitation for residential is maintained.

2) Intermediate Load Forecast - the residential sector installs 100 or 125 A breakers, uses new and larger appliances but electric heat is not allowed.

3) High Load Forecast - present services install 125 A or larger breakers and services upgraded to handle electric heating.

Future energy requirements were then projected in view of estimated population growth and related service requirements. Table ES-2 summarizes these future requirements in terms of the three (3) electrical load alternatives identified above.

Continued low load electrical supply will necessitate the utilization of oil for institutional heating, wood for residential heating/cooking, gasoline for wood procurement and general transportation and propane for some institutional cooking applications. These comprehensive energy requirements were projected for 25 years so as to accommodate the needs of anticipated future population levels.

Intermediate load electrical supply will enable the communities to utilize larger electrical appliances, power motors, etc. as is the common practise for grid-connected communities. However,

Projected Energy Requirements
Brochet & Lac Brochet

Table ES-2

	Present 1982/83	1988	1993	1998	2003	2008
Low Load						
Brochet:						
Diesel (kw/mWh)	210/886	246/1040	271/1159	406/1716	446/1899	496/2125
Oil (l)	303,464	303,464	303,464	436,800	436,800	436,800
Wood (Cords)	1,001	1,386	1,661	1,991	2,431	2,970
Gasoline (l)	65,156	90,216	108,116	129,596	158,236	193,320
Propane (kg)	2,190	2,190	2,190	4,630	4,630	4,630
Lac Brochet:						
Diesel (kw/mWh)	66/270	129/512	149/599	196/803	221/931	248/1059
Oil (l)	76,910	122,120	124,120	190,000	192,000	194,000
Wood (Cords)	495	770	990	1,210	1,485	1,760
Gasoline (l)	43,245	67,270	86,490	105,710	129,735	153,760
Intermediate Load						
Brochet (kw/mWh)	210/886	585/2143	816/2721	1097/3757	1265/4307	1475/5000
Oil/Wood/Gasoline same as Low Load - Propane not required						
Lac Brochet (kw/mWh)	66/270	302/985	447/1559	612/2016	747/2946	852/2793
Oil/Wood/Gasoline same as Low Load - Propane not required						
High Load						
Brochet (kw/mWh)	210/886	1421/4815	1765/5759	2554/8566	2901/9436	3337/11172
Wood (cords 20% Low Load)	200	277	332	398	486	594
Gas (L - 20% Low Load)	13,030	18,045	21,623	25,920	31,467	38,664
Oil/Propane not required						
Lac Brochet (kw/mWh)	66/270	766/2471	1144/3651	1451/3651	1768/5631	1991/6368
Wood (cords 20% Low Load)	99	154	198	242	297	352
Gas (L - 20% Low Load)	8,649	13,454	17,298	21,142	25,947	30,752
Oil/Propane not required						

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intermediate electrical load service will not significantly displace other (wood, oil, gasoline) energy sources which are utilized primarily for heating purposes. Propane would no longer be required as electricity will be utilized for major appliances, water heating, etc.

High load electrical supply will enable the communities to utilize electricity for all major applications including heat. Approximately 20% of low load wood/gasoline projections are included in high load assumptions to account for individuals who would not convert to electric heat as well as the continued utilization of wood/gasoline as a back-up heating system.

5. Cost Considerations

Three (3) electrical energy supply alternatives were analyzed in order to satisfy the aforementioned load forecasts. The alternative electrical supply developments include: continued diesel operation, small hdyro electric development and transmission tie-in to the Manitoba Hydro grid at Lynn Lake.

Diesel unit additions were based upon growth estimates and discussions with Manitoba Hydro. Initial estimates of $500/kw installed were increased by 8% per annum in order to reflect inflation.

Brochet:	New Diesels Installed (kw)	Inflated Installed Cost ($)
Year: 1987	350	$ 323,000
1994	300	350,000
2002	600	1,296,000
2009	300	1,110,000
Lac Brochet:		
Year: 2004	525	1,320,000

Diesel operating and maintenance (o/m) charges were based upon actual Manitoba Hydro data and were increased according to load requirements and inflation assumptions.

Several potential sites have been located on the river between Lac Brochet and Brochet, and compared for a range of possible hydroelectric development sizes. While study has indicated that the river flow is suitable for hydroelectric development, the

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sites for development are of limited head, which results in a relatively costly plant and equipment. The most economical site for capacities up to about 3,000 kw has been identified at the rapids about 14 km northeast of Brochet. For capacities greater than about 3,500 kw, the most economical scheme has been determined to be the diversion of a portion of the Cochrane River flow through Engen Lake to a dam and powerhouse located near an arm of Birch Bay.

Capital costs for potential hydroelectric development have been estimated as follows:

Hydroelectric Development
Capital Cost Estimates ($-1984 - 000's)

	Single Site Brochet and Lac Brochet	Brochet Alone	Lac Brochet Alone
Low Load	$13,500	$ 7,900	$ 8,800
Intermediate Load	18,200	11,500	10,400
High Load	27,800	n/a	n/a

These capital costs estimated include all labour, materials, transportation, storage and interest costs assuming a three (3) year construction period.

Operation and maintenance costs for hydroelectric alternatives were estimated at 1.7% of capital cost and include the cost of energy. Operating and maintenance costs were then projected to account for inflation and development expansion.

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Transmission line tie-in with the Manitoba Hydro grid system at Lynn Lake is a plausible alternative. Capital costs for transmission line tie-in including labour, materials, transportation and interest during construction have been estimated as follows:

Transmission Tie-In
Capital Cost Estimates ($-1984 - 000's)

Lynn Lake-Brochet	$ 7,680
Brochet-Lac Brochet	5,460
Total	$13,140

Capital cost estimates for transmission tie-in have been verified with Manitoba Hydro.

Operation and maintenance costs for transmission tie-in have been estimated at 1.2% of capital cost. The additional cost of energy provided by the grid connection at Lynn Lake has been initially identified by Manitoba Hydro at 1.74¢/kWh. Operation and maintenance energy charges were projected in order to account for load growth and inflation.

6. Financial Analysis

The various energy alternatives were analyzed by examining the total energy requirements of the two communities including electricity, oil, wood/gasoline and propane as discussed. All capital, operation/maintenance, and energy costs were projected forward on the basis of determined load projections assuming a rate of inflation of 8%. The capital cost of the various alternatives was amoritized over the useful economic life of the various developments. These flows were discounted at 12% thereby resulting in an effective discount factor of 4%.

The present value analysis applied to the various alternatives is presented in Table ES-3.

Of all the alternatives considered, transmission line tie-in under high load energy assumptions is the most economical alternative for the communities. High load (electric heat) will enable the study communities to virtually eliminate costly heating oil and wood/gasoline consumption at an overall cost which is much cheaper than the present energy system or a hydroelectric development. Transmission line (from Lynn Lake) construction costs are the most economical of any of the enhanced electrical energy alternatives and therefore contribute significantly to the overall energy cost reduction.

Hydroelectric alternatives comprise the greatest capital cost of any of the enhanced electrical energy alternatives. Hydroelectric development also entails the most economical operation and maintenance energy costs of the enhanced electrical supply alternatives. It is therefore observed that the high capital cost of hydroelectric development places this alternative in the

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highest overall cost category of enhanced energy alternatives.

Diesel generation is the most costly of all the energy alternatives considered. While diesel generation comprises the least capital cost, limited diesel generated electricity and associated wood/gas/oil requirements also comprise the highest operation/maintenance and energy costs which enable reduced 15 amp. diesel generation to be compared to the other alternatives from a cost effectiveness viewpoint. Limited 15 amp. diesel service with related wood/gas/oil requirements will cost the study communities approximately $155 k ($-1984) per year more, for the next 25 years, than installing a transmission line from Lynn Lake and providing electric heat.

All other variations concerning separate developments or tie-ins are more costly than the transmission tie-in for Brochet/Lac Brochet discussed above.

7. Community Concerns

Present rate conditions are such that electric heat conversion, assuming grid tie-in, would cost residents only $5 - $10 per month more than is presently paid for limited 15 amp. service and the cost of wood procurement. The local survey indicated that 90% of study area residents would convert to electric heat if costs would be similar to average monthly charges presently incurred in obtaining wood resources. In view of the above, transmission line electric heat would not only be desireable but also economically acceptable to study area residents.

Environment impacts of either intermediate load hydroelectric or transmission line connection would not be too significant. Concern would rest with a slight elevation in river level, minimal flooding, aesthetics of road/transmission access and possible effects upon caribou migration. Specific study would be required prior to development.

Table ES-3

Present Value Energy Costs (1984 dollars)
Brochet and Lac Brochet
Inflation 8%, P.V. Discount 12%
Projection Period 1985 - 2009

(000's)	Amortized Cap. Cost	O/M	Energy Cost	Total Cost
Continued Diesel - Low Load:				
Brochet (including oil, propane, wood/gas)	840	4,617	6,513	11,970
Lac Brochet (including oil, propane, wood/gas)	330	5,386	3,392	9,108
Total	1,170	10,003	9,905	21,078
Hydroelectric - Intermediate:				
Brochet - Lac Brochet (including wood/gas, oil)	14,610	3,463	9,703	27,776
Brochet Only (including wood/gas, oil)	9,580	2,219	6,482	18,281
Lac Brochet Only (including wood/gas, oil)	8,443	1,955	3,221	13,619
Hydroelectric - High:				
Brochet & Lac Brochet (including wood/gas)	23,144	3,414	953	27,511
Transmission Line:				
Brochet & Lac Brochet - Intermediate (including wood/gas, oil)	11,839	1,918	10,917	24,674
Brochet & Lac Brochet - High (including wood/gas)	11,839	1,918	3,436	17,193
Brochet Only - Intermediate (including wood/gas, oil)	6,919	1,170	7,254	15,343
Brochet Only - High (including wood/gas)	6,919	1,170	2,285	10,374

NORTH CENTRAL MANITOBA ELECTRIFICATION STUDY

EXECUTIVE SUMMARY

Manitoba Hydro has, over the past decade, provided electric energy to the North Central communities of Garden Hill, Gods Lake Narrows, Gods River, Oxford House, Red Sucker Lake, St. Theresa Point, and Waasagomach. This electric energy is generated by means of local diesel generating plants located in each community and distributed through local, independent distribution systems.

The use of electrical energy in each of the communities is restricted to 240 volt, 15 amp service for standard residential customers and 240 volt, 30 amp service for standard general service customers. Customers requiring unlimited electric energy can obtain this type of service under a special agreement with Manitoba Hydro whereby they pay the full cost of providing the service. These charges are considerable and include monthly energy charges as well as a one-time front-end generation charge of anywhere from $545 to $2,130/kw. The energy and generation costs relate to Manitoba Hydro's incurred costs to finance, construct, operate, maintain, expand, and replace the plant and equipment supplying the energy. The charges vary from time to time and from community to community.

Continuing long-term escalation in the cost of both fuel oil and its transportation to the communities, as well as the Canadian Government's off-oil initiative prompted the Island Lake Tribal Council to apply on behalf of all the North Central communities for the funding of a study under the Remote Community Demonstration Program. The study was to identify feasible alternatives for the supply of economical, unlimited electrical energy to the customers in the seven communities. The funding to carry out the study was made available jointly by the Department of Energy, Mines and Resources and the Department of Indian Affairs and Northern Development.

Under existing conditions, Manitoba Hydro provides diesel-generated electric energy to the communities and has incurred large annual losses. It is anticipated that due to the continuing escalation of fuel oil prices and transportation costs, these losses will continue to rise. In order to examine feasible alternatives to diesel generation, population and electrical consumption projections were prepared, based on current statistics.

Existing consumption in the communities was divided into the major consumer groups: residential, street lighting, general service commercial, federal government funded facilities, and provincial government funded facilities.

The most critical assumptions in projecting load growth in communities, where very little commercial and industrial load growth is anticipated, are those associated with space heating of residential, commercial and institutional facilities. A review of Manitoba Hydro statistics for other northern communities provided with unrestricted electrical energy shows that in the majority of cases, residential customers in those communities presently opt for all-electric service which includes electric space heating. This despite the fact that in many cases, wood is readily available, more economical, and may be necessary for standby emergency heating. The overriding considerations with residential customers seem to be the safety, reliability, and convenience of electric heating systems. Should the cost of electrical energy continue to escalate, the general acceptance of electric heat may change, but this has not yet occurred. General service customers including government funded agencies presently utilize fuel oil to provide the majority of space heating requirements in the North Central communities, with a relatively small percentage of space heating being provided by wood and propane. Residential customers presently use wood for space heating requirements.

Once energy demands and peak loads were established, the following electrical energy supply alternatives were reviewed:

1. Central System Supply

A transmission system connection from the northern Manitoba Hydro grid to the North Central communities was investigated in detail. This transmission line would be approximately 160 km long and would originate at Kelsey Station near Kelsey and would terminate at Oxford House, the closest North Central community to Kelsey. The individual communities would be interconnected with a transmission grid. Other transmission system connections to the Manitoba Hydro northern and southern transmission grid were considered but not investigated further due to much higher capital costs.

Connection of each community to the transmission grid will require either new transformer stations to interface to the existing community distribution systems or upgrading of the community distribution systems to permit direct connection to the grid. The costs of the various alternatives were investigated on a community basis and only the most economic alternative was considered.

Individual householders and commercial and institutional customers would have the option of upgrading their services to make full use of the electrical energy available to the same degree as a southern consumer. This cost, however, would be the responsibility of each consumer.

2. Local Hydro Generation Alternative

Seven potential hydro sites were identified and studied in detail. A site reconnaissance was also carried out to verify the available data for each site and to assess and ascertain site-specific features.

The sites are located on the Gods, Kanuchuan, and Island Lake Rivers which in turn are connected to Gods Lake and Island Lake, the two major lakes characterizing the study area.

Although other sites in the area may have the potential for development, the sites chosen can be considered representative and offered the added advantage of making use of virtually the entire head available on the rivers.

Each hydro development would be connected to a transmission grid which in turn would provide the electrical interconnection between the communities and the hydro plants. Transmission grid voltages were selected, based on preliminary load flow studies. As a result of these voltages, new transformer stations and upgrading of some of the existing community distribution systems would be required to facilitate connection to the transmission grid.

3. Alternative Energy Systems

A variety of alternative energy sources for generation of electrical power were also analyzed. These included:

- Diesel generation
- Wood-fired boiler/steam turbine generation
- Wood gasification dual-fuel engine generation
- Solar energy generation
- Wind energy generation
- Peat-fired steam turbine generation
- Hybrids

For the purposes of this analysis and for technical and economic reasons, an energy supply from a centralized plant, located at Gods Lake Narrows, was deemed preferable and all units were assumed to be located at this site.

While advanced technology has been reviewed, only proven technology has been considered and evaluated. A preliminary screening of all of the above primary alternatives revealed that only the diesel generation and wood-fired boiler/steam turbine generation alternatives, as well as a solar extension to each of the above, were economically viable solutions.

After reviewing the three categories of alternatives discussed above, it was determined that on an economic and technological basis, the central supply system and the local hydro generation alternatives were the most feasible choices, warranting detailed analysis. This analysis was carried out and, based on an economic comparison, the Central System Alternative proved to be the most viable by a wide margin.

The economics of the various alternatives considered were compared by calculating the present worth as at January 1, 1989 of all capital, operating, maintenance, and fuel costs not common to each alternative over the period to 2015. The results of this comparison are summarized below.

Alternative/Item	Present Worth in Millions $ at Discount Rates of		
	4%	6%	8%
Central System Supply Alternative			
Fixed Charges - transmission line	9.68	10.55	11.31
- transmission grid	22.28	22.82	23.12
Operation and maintenance - line	1.84	1.59	1.30
- grid	3.84	3.19	2.60
Energy Costs	14.28	11.00	8.68
Total	51.92	49.15	47.01
Local Hydro Supply Alternative			
Fixed Charges - hydroelectric plants	57.12	64.15	68.05
- transmission grid	18.13	18.52	18.82
Operation and Maintenance - plants	10.59	8.78	6.76
- grid	3.07	2.58	2.10
Total	88.91	94.03	95.73

Local Thermal Supply Alternative - Biomass

Fixed Charges - generation plant	45.15	44.07	42.83
- transmission grid	18.13	18.52	18.82
Operation and Maintenance - plant	23.75	18.50	14.74
- grid	3.07	2.58	2.10
- variable	1.99	1.53	1.21
Fuel Costs	61.29	47.22	37.24
Total	153.38	132.42	116.94

Local Thermal Supply Alternative - Diesels

Fixed Charges - generating plant	20.56	19.52	18.58
- transmission grid	18.13	18.52	18.82
Operation and Maintenance - plant	12.35	9.62	7.66
- grid	3.07	2.58	2.10
- variable	8.25	6.36	5.02
Fuel costs	55.93	43.09	33.99
Total	118.29	99.69	86.17

Note: The above present worth figures are for relative comparison purposes only, and cannot be used to calculate the price of energy to the customer.

A preliminary environmental evaluation was prepared for the two primary alternatives. Impacts arising from a central supply system would be primarily associated with trapping. Line construction in the winter might disturb wildlife along the right-of-way, causing them to move out of the area, and resulting in a temporary decreased fur harvest. Trappers might require compensation, but the impact would be temporary. Some increased hunting of ungulates along the right-of-way is a potential long-term impact. The local hydro generation alternative would result in both of these impacts as well. The most serious impacts of small hydroelectric generating stations would be the destruction of the prime brook trout habitat and interference with fish passage in the Gods Lake area. Brook trout populations would decline and lodges depending on the species for attracting business would be negatively affected.

A preliminary socio-economic assessment showed that the primary impacts would be similar for the two alternatives. Upgrading of the electrical system in the North Central communities would offer temporary employment and income opportunities for interested local residents. Local roads may require upgrading for the project which could in the long term benefit the communities. However, those residents opting to upgrade their electrical services would experience a continuing cost increase due to their increased use of electricity, with or without electric space heating. The significance of this increase would depend on their assessment of a superior electrical supply.

The results of this study were reported to the residents of the communities in order to elicit public comment and discussion. The residents, virtually unanimously, opted for the recommended alternative, a connection to the Manitoba Hydro Central Grid at Kelsey. Furthermore, the residents in some of the communities rejected completely the Local Hydro Generation Alternative as a result of the potential impact on the natural resources in the area.

In conclusion, the preferred option for the provision of unrestricted electric service to the North Central communities from economic, environmental, social, and public aspects is a connection from the communities to the Manitoba Hydro Central Grid at Kelsey.

PREFEASIBILITY STUDY OF MINI-HYDRO POTENTIAL IN THE VICINITY OF WASKAGANISH, QUEBEC

Executive Summary

The community of Rupert House is seeking the most economical and socially accepted source of energy supply to satisfy its forecasted demand for the next 50 years.

Rupert House, located at the mouth of the Rupert River, is accessible by boat via James Bay during the open navigation season, by plane via scheduled flights of Air Creebec or by helicopter. For the benefit of the building activity in the community, a winter road is maintained from the village to Matagami-LG2 road. A segment of this road--its first 20 km--represents a permanent access road to the sand barrow pit presently under exploitation.

This report considers the possibility of developing mini-hydro plants at six sites on the Pontax River, three sites on the Rupert and two on tributaries of the Broadback.

The study found that the most favorable site is located on the Rupert River at Kaoposcuan Sibostak, some 35 km from the village. It would require an initial investment evaluated at $10,600,000 for a 1 MW capacity station and would cost $25,500,000 for a 5.7 MW development.

A big part of the investment is to cover the costs of a new access road and a transmission line (a minimum of $4,400,000 in direct costs only).

Supplementary justification for opening the access road, such as the wood supply activity or even a permanent link to the Matagami-LG2 road, would be an incentive toward the development of a mini-hydro energy source.

The study was undertaken by Asselin, Benoit, Boucher, Ducharme, Lapointe Inc. of Montreal for the Cree Regional Authority with a contribution from the Remote Community Demonstration Program of Energy, Mines and Resources Canada.

A comparison study, entitled "A Comparative Study of Energy Systems for Waskaganish, Quebec", analyzes the community's energy options.

*Waskaganish was formerly known as Rupert House and Fort Rupert.

A COMPARATIVE STUDY OF ENERGY SYSTEMS, WASKAGANISH, QUEBEC

1. EXECUTIVE SUMMARY

Objective

The objective of this study was to determine which energy supply scenario could provide energy at the lowest cost for Waskaganish.[1] This analysis has to be performed following a clearly defined approach.

General Approach

The study is divided into four parts:

- the assessment of the Total Energy Demand;
- the definition of eight energy systems able to meet this Demand;
- the definition of the energy supply scenarios available for Waskaganish;
- a comparative analysis of these scenarios.

The Total Energy Demand was first estimated for 1983-1984 and then forecasted for the next fifty years. The Total Energy Demand was then broken down by sector and final use. The houses managed by the Cree Housing Corporation were taken to constitute the Residential Sector while all other buildings were included in the Commercial and Institutional Sector. Two final uses were considered in this study: the basic needs (all uses not related to heating e.g. lighting, cooking, refrigeration, appliances) and the heating needs. The forecasts are based on population growth estimates.

Eight energy systems are studied as specified in the Terms of Reference. These systems are:

- diesel generators
- oil furnaces
- wood furnaces
- thermoelectric generators
- wood gasifier
- windmills
- mini-hydroelectric power plant
- interconnection with the Hydro-Quebec grid.

The wood furnaces are only considered for the Residential Sector. Cost evaluation of the mini-hydroelectric power plants is derived from the ABBDL-TECSULT study entitled "Prefeasibility study of mini-hydro potential in the vicinity of Rupert House". This study proposed two alternatives, a 5.7 MW power plant meeting the total energy demand for thirty years and a 1.0 MW power plant meeting the basic electricity demand for thirty years. The present study being done for fifty years, the cost estimates have been redone for two larger power plants: 2.5 MW power plant to meet the basic demand and a 10 MW power plant to meet the total demand for fifty years.

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[1], [2] See page x

The eight energy systems are then combined to form the energy supply scenarios available to the community. A first selection of the more logical scenarios is performed at this level to retain three to six true alternatives for Waskaganish.

These scenarios are evaluated based on their total cost for a fifty year period and on their social and environmental impacts. Conclusions and recommendations follow identifying the optimal energy supply scenario for the community of Waskaganish.

Conclusion and recommendations

The total energy demand in 1984 is estimated at 7 190 703 KWh and will reach 25 058 871 KWh in 2033. The total peak demand load is estimated at 2.9 MW in 1984 and will rise to 10.0 MW in 2033.

Following the presentation of the eight energy systems previously enumerated, three were discarded for technical reasons. They are: the gasifier, the thermoelectric generator and the windmill.

Fifteen energy supply scenarios were then formed from the various combinations of the remaining five energy systems.

Ten were quickly discarded for obvious reasons, leaving five valid energy supply scenarios to be studied thoroughly. They are:

	Energy systems providing	
Scenarios	Basic energy	Heating energy
Scenario #1	Diesel generators	Wood furnaces Oil furnaces
Scenario #2	Transmission line	Wood furnaces Transmission line
Scenario #3	2.5 MW mini-hydro	Wood furnaces Oil furnaces
Scenario #4	10 MW mini-hydro	10 MW mini-hydro
Scenario #5	Transmission line	Transmission line

Since a previous report[3] prepared by COGESULT recommended for the residential heating an energy mix including 75% wood - 25% oil, it is assumed that the wood furnaces will supply 75% of the residential heating needs in the scenario #1, #2 and #3.

The present diesel generators are considered available without extra cost. Since they are owned by Indian and Northern Affairs Canada, this matter will have to be negotiated. The present salvage value of these equipment is 648 000$.[4]

The present worth of these scenarios is presented in Table 1.

Table 1

Present Worth of the energy supply scenarios (discount rate = 4%)

Scenarios	Present Worth
Scenario #1	41 357 000$
Scenario #2	37 538 000$
Scenario #3	30 037 000$
Scenario #4	43 563 000$
Scenario #5	36 908 000$

A discount rate of 4% is used to calculate the Present Worth of each scenario. A sensitivity analysis is presented for variations of the discount rate.

The scenario #3 remains the cheapest with discount rates of 2 and 6%. The scenario #1 which includes utilization of diesel generators for basic electricity production is very sensitive to the discount rate variations. It is the more expensive scenario at 2% and the least expensive at 8%.

No scenario has a significant impact on the environment. On the social side, the scenario #3 generates the greater level of economic activity, on short and long term basis. Utilization of wood furnaces however requires more attention from the user. Scenario #4 and #5 have only a short term impact on the local economic activity.

[3, 4] See page x

Cogesult consequently recommends to the Cree community of Waskaganish to adopt the scenario #3 which implies wood and oil heating for the residential sector, oil heating for the commercial and institutional sectors and the construction of a 2.5 MW mini-hydroelectric power plant to provide the basic electricity to the whole community.

Cogesult also recommends to the Cree community to study the possible benefits related to the implementation of an energy management system which would recuperate the energy surplus occasionnally generated by the mini-hydro. This would reduce the cost of this scenario.

It is assumed in this study that the construction cost of the transmission line was not negotiable. A financial participation of Hydro-Quebec in this project could make the scenarios including the transmission line more interesting. Cogesult recommends that the Cree community undertake such negotiations with Hydro-Quebec before making a final decision on the adoption of such an energy supply scenario for Waskaganish.

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[1] Waskaganish was formerly known as Rupert House and Fort Rupert

[2] The study entitled "Prefeasibility Study of Mini-Hydro Potential in the Vicinity of Waskaganish, Quebec" was prepared for the Council of the Crees of Waskaganish and for the Cree Regional Authority with a contribution from the Remote Community Demonstration Program of Energy, Mines and Resources Canada. (April 1984)

[3] Firewood Demand and Supply Study for Eastmain, Wemindji and Waskaganish, September 1984, p. 53. The report was prepared for the Grand Council of the Crees (of Quebec) and the Cree Regional Authority with financial contributions from Indian and Northern Affairs Canada and the Remote Community Demonstration Program of Energy, Mines and Resources Canada.

[4] Straight-line amortization and utilization rate of 50%.

EXECUTIVE SUMMARY

Based on an unsolicited proposal, a contract was awarded to Fenco Newfoundland Limited by the L'Anse au Clair Community Council to investigate the technical and economic feasibility of a mini-hydro development in that area. Funding for the study was provided by Energy Mines and Resources Canada under the Remote Community Demonstration Program (RCDP) and the Community Council of L'Anse au Clair.

L'Anse au Clair, a small community on the extreme south coast of Labrador, is one of eleven (11) communities supplied with electrical energy by a 2000 kW firm capacity diesel generator station located at L'Anse au Loup. It is the third largest user of electricity of the eleven (11) communities, making up approximately 13% of the annual energy demand in 1982.

The proposed development is located approximately 0.5km east of L'Anse au Clair, on Eastern Brook, with a catchment area of approximately 25 km^2.

The nearest river with streamflow records is the Saint Paul River in Quebec which is approximately 45 km west of Eastern Brook. This streamflow data was used to estimate the seasonal variation of Eastern Brook's streamflow as a function of its mean annual flow which was estimated as 70% of the mean annual total precipitation. The resulting flow data compared well with recorded streamflows for two other larger rivers further north with the main difference being an earlier thaw generated flow and a more even distribution of seasonal flows for Eastern Brook. Daily flow duration curves and flood frequency curves were then produced.

The basic scheme consists of:

(a) a 65m long intake dam of compacted till with an excavated, 30m wide spillway channel,

(b) a 1000m long penstock (800mm diameter),

(c) a 314 kW powerhouse,

(d) access roads to the powerhouse and intake dam,

(e) a 12.5 kV transmission line connecting the generator to the existing distribution system,

(f) a possible upstream storage reservoir.

The turbine selected was an Ossberger (cross-flow) type which provides a relatively flat efficiency curve from 20 to 100% power output and can operate adequately at an output of 10%. The selected turbine generator set would have an electrical full output of 314 kW. The turbine would be rated at a peak output of 443 HP (330.5 kW), with a net head of 66.4m and a plant discharge of $0.62m^3/s$ at full output.

An alternative smaller scheme, with an installed capacity of 192 kW, was also examined. The major civil works components would be unchanged except for the use of a smaller diameter (630mm) penstock.

The turbine selected for this smaller scheme is of the same type as the larger one. The turbine would be rated at a peak output of 271 HP (202 kW), with a net head of 65.22m and a plant discharge of $0.384m^3/s$.

Essentially, a reduced scheme was considered to avoid upgrading the existing single phase transmission line between L'Anse au Clair and Forteau, a distance of 10.5 km. This would reduce the capital investment required to implement the project. However, it is realized that an upgrading of the transmission line would be a benefit to the utility because the existing poles are in need of replacement.

The proposed hydro plant will operate in parallel with the existing diesel generating system. The project evaluation is based on the economics of replacing diesel generation from existing units only.

The geology of the area consists of formations of the Labrador Group of Lower Cambrian sediments. These contain shale, siltstone, limestones and sandstones. There is exposed bedrock at the proposed intake dam and storage dam sites. There is also exposed bedrock in numerous areas along the penstock route. Bedrock was not evident at the powerhouse site. Construction materials such as rock, sand, gravels, and till are available in and around the L'Anse au Clair area.

Technically, no abnormal engineering problems are anticipated with constructing this project. In order to complete the project by the fall of 1987, a start time of April, 1986, will be necessary. This will allow enough lead time on the manufacturing and delivery of the turbine and generator. The actual construction can be completed from May to October of 1987.

Based on real and projected 1985 prices, the capital cost for the basic 314 kW run-of-the-river scheme is $1 579 640. This includes $240 000 estimated for upgrading the present single phase line from Forteau to L'Anse au Clair to 3 phase.

Capital cost for completing the reduced 192 kW scheme is $1 124 920 including the transmission lines to the town's single phase distribution system, estimated at $30 000.

An analysis was carried out to determine the benefits of constructing a storage dam upstream. Storage cost and benefit comparisons show that while a storage reservoir would result in useful benefits, the economics of adding the facility are very marginal. It did suggest, however, that if this project is developed further, storage options should be re-examined.

Other than the concerns expressed by Fisheries and Oceans concerning stream flows in Eastern Brook, the proposed development does not appear to pose any serious environmental problems. Except for the construction phase, the development will have no appreciable impact upon the community. The construction phase of the project will require 150 man-months of employment.

The projects were evaluated in terms of new hydro energy used to replace generation from diesel units, i.e., at the variable cost of diesel generation. No storage was considered. Based on these considerations, the basic evaluation of the hydro alternatives is based on direct comparison of hydro total and diesel variable generation costs, excluding escalation. This provided a direct measure of the mobility of the hydro projects as a function of interest rates.

The variable cost of diesel generation, i.e., excluding any capital related charges for equipment, is made up of fuel costs, lubricating oil costs, and variable operation and maintenance costs. Based on these costs, it was assumed that the total variable diesel generation cost for L'Anse au Loup is 16.5 ¢/kWH.

The calculation of unit hydro electric generation costs is based on capital related charges of interest, depreciation, interim replacement, and insurance plus actual operation and maintenance costs, and general administration or overhead.

Based on a service life of 35 years, a comparison of these hydro generation costs with the variable or displacement values of diesel generation, which is 16.5 ¢/kWH, yields the corresponding breakeven interest rates of:

	BREAKEVEN INTEREST RATES	
	314 kW	192 kW
Hydro plant only	14.7%	13.3%
Hydro plus transmission	12.3%	12.9%
Hydro plus transmission costs increased by 10%	11.1%	11.7%

The above values show that if transmission line construction costs are excluded, both the 314 kW and 192 kW schemes are quite attractive. With transmission costs added, both projects are still economically viable by accepted Canadian standards, based on the replacement of fuel criteria. The 314 kW project would displace more expensive diesel fuel, however, the reduced scheme feasibly is more attractive because of its low transmission capital costs.

Before commencing with this project, it is recommended that further plan and profile surveys be undertaken, along with more extensive geotechnical investigations. Storage facilities should be reassessed as well as a reappraisal of the fisheries requirements.

1 INTRODUCTION

.1 General

The study reported herein was undertaken by Newfoundland and Labrador Hydro under the Remote Community Demonstration Program of the Department of Energy, Mines and Resources, Canada.

The Department of Municipal Affairs of the Province of Newfoundland and Labrador are proceeding with a water supply and sewage system for the community of Mary's Harbour, Labrador. At their proposed dam site there is potential for a mini-hydro development.

The hydro site was previously identified in the Newfoundland and Labrador inventory "Study of Small Scale Hydro" prepared by ShawMont Newfoundland Limited. Shawmont Report # SM-2-79.

The approval of the water supply and sewage system for Mary's Harbour by the Department of Municipal Affairs presented a new opportunity to review the Hydro project in relation to a joint development utilizing common facilities.

The purpose of this study was to determine the technical and economic feasibility of the mini-hydro development with the integration of the mini-hydro project with the community water supply and sewage system.

The study was jointly funded by the Department of Energy, Mines and Resources, Canada, the Department of Municipal Affairs of the Province of Newfoundland and Labrador, and Newfoundland and Labrador Hydro.

.2 Proposal and Agreements

Newfoundland and Labrador Hydro submitted a proposal for a study of a mini-hydro development at Mary's Harbour, Labrador, under the Remote Community Demonstration Program in a letter to the Department of Energy, Mines and Resources, Canada dated 1983 04 12.

A study agreement was approved by the Department of Energy, Mines and Resources, Canada in their letter to Newfoundland and Labrador Hydro dated 1983 07 26.

MINI-HYDRO/WATER SUPPLY FEASIBILITY STUDY FOR RIGOLET, LABRADOR

ABSTRACT:

This study was carried out for the Community of Rigolet, Labrador and funded under the Remote Community Demonstration Program of Energy Mines and Resources Canada with contributions from the Department of Municipal Affairs of the Province of Newfoundland and Labrador and Newfoundland and Labrador Hydro.

The study investigates the economics and technical feasibility of combining a water supply and a mini hydro project in the remote coastal Labrador Community of Rigolet.

The hydro power generated would reduce that required to be produced by the four (4) existing diesel power generation units with resultant fuel cost savings.

The proposed scheme combines pumping, siphon action and gravity flow to two (2) impeller turbines. Water is fed to the turbines through a 610 mm diameter 2480 metre long penstock by a propeller pump located in a vertical intake pipe. The penstock is a siphon and the pump is used to add head at the intake thereby reducing the siphon head and consequently the negative pressures at the high point of the siphon.

The turbines will operate under steady state conditions with load changes accommodated by an electronic load governor rather than gates, enabling the flow to the turbines to remain constant and thereby eliminating hydraulic transients in the penstock.

The system has been sized to meet as closely as possible the demand during the months from May to November, and the available flow from inflow and storage during the months from December to April consistent with the most economical penstock size and dam height.

Water is supplied to the Community through the existing distribution piping system tapped to the penstock above the turbines.

The capital cost of the joint project is estimated at $2,630,000.00 in 1986 dollars. The project can be completed in approximately eight working months but because of severe winter conditions and equipment delivery times the actual time required to complete the project will be sixteen (16) months.

The results show that the joint project is cost-effective with cross-over occurring in nineteen (19) years.

The project is technically feasible and demonstrates several unique features in hydro system design.

INVESTIGATION OF THE VIABILITY OF A REMOTE WIND/HYDROELECTRIC POWER SUPPLY IN THE NORTHWEST TERRITORIES

EXECUTIVE SUMMARY

STUDY OBJECTIVE

This report covers the first phase of a study of which the objective is to investigate the viability of using a pumped-storage wind/hydro-electric supply system for meeting specific isolated electrical loads in the Northwest Territories. In such a system, energy would be extracted from the atmosphere through the use of windmills or wind turbines and the load would be supplied by methods incorporating storage of water in a high-level reservoir for release through hydro-electric turbine/generators as required. For specific cases, a wind/hydro system may have the potential to replace diesel-electric generation where other alternatives are less viable.

SCOPE

In the first phase of the study the physical characteristics of a stand-alone wind/hydro system are developed. In particular, and within the perspective of possible implementation in isolated northern regions:

(a) a review of recent progress in wind-energy conversion technology is used as a basis for suggestion of potentially promising combinations of wind turbines, drives, and pumps;

(b) hydro-electric subsystem considerations are reviewed in the wind/hydro context in which the provision of firm flow for hydraulic turbine/generators is necessarily a part of the design of the wind-energy conversion subsystem; and,

(c) for conceivable stand-alone wind/hydro system configurations, the basic relationships among electrical demand, wind turbine capability, storage capacity, reservoir storage elevation, and installed hydro capacity are examined using a typical Northwest Territories wind regime and typical load characteristics.

FINDINGS OF INVESTIGATION INTO STAND-ALONE WIND/HYDRO SYSTEMS

Several wind turbine types in the 100+ kW sizes have potential for application in remote wind/hydro-electric supply systems. Design features of various lightweight horizontal- and vertical-axis wind-electric generators and low-speed, multi-bladed, horizontal-axis machines result in differences in power output among units, but other factors affecting pumping, siting, and operation of a small electricity-supply system are expected to have greater importance in wind/hydro system design. Before the most promising wind-turbine-and-pump combinations can be identified, more needs to be understood about some of these determining factors, i.e.,

(a) the separation of mechanically linked wind turbines and pumps,

(b) operation of wind turbines at variable speeds with delivery of mechanical energy from the wind turbine rotor shaft,

(c) the effect of wind generator output power quality on the local grid, and controls to improve this quality, and

(d) performance of wind turbines and pumps in the severe northern environment.

The required understanding may be gained from further research and development, and from northern field trials.

The more favourable wind regimes near isolated communities in the Northwest Territories exhibit long-term average windspeeds which are at the low end of the operating ranges of contemporary wind turbines. Extended intervals in which average windspeeds are significantly below long-term values produce long critical periods for system component sizing (they can be on the order of weeks to months in duration). The result is a requirement for large installed nominal windpower capacity and reservoir storage capacity compared to the size of the load.

STUDY CONCLUSIONS AND RECOMMENDATIONS

The lack of dependability in the wind as an energy source in the Northwest Territories thus would suggest that, for the isolated electricity supply systems, windpower may be more appropriately used in a supplementary or fuel-saving role. For existing or potential hydro-electric developments, firming of system energy could be effected with the use of wind- and/or diesel-electric generation to substitute for withdrawals from storage, or with the use of wind-powered pumping to augment reservoir inflows. For existing diesel-electric systems, windpower, when available, could be used to reduce fuel consumption. As some experience has been gained already with such systems across the country (including some in the Northwest Territories), experimental-scale operation of various windpower systems in the north reasonably could be initiated and the less-understood aspects noted above could be investigated. The possibilities for use of wind turbines for remote community water supply applications could be studied at the same time.

Exploration of all avenues for maximization of unit wind-energy production is also required to hasten the economic viability of wind turbine applications in the north. The physical situation near a load centre could allow exploitation of an anomalous localized wind regime in cases where the estimated wind-energy potential for the region would have been pessimistic. Unusual wind resources which are within practical distances of communities should be identified and quantified.

For the optimal utilization of wind as a supplementary energy source in a system which involves hydro-electric generation, an appreciation of the joint availability of water and wind is important. Although short-term wind is not a dependable resource, its longer-term effect is a firming of energy through augmentation of storage or avoidance of reservoir withdrawals. Study of the natural wind-water time dependence in the Northwest Territories context would be appropriate to precede further wind/hydro investigations.

ENERGY CONSERVATION AND WIND ENERGY FEASIBILITY STUDY FOR KITKATLA, B.C.

SUMMARY

This report documents a study of energy supply and use for the community of Kitkatla, a stable community of approximately 500 people on the north coast of B.C. The community of Kitkatla presently spends $352,800 per year on various fuel supplies for heating, electrical production, fishing and community and school buildings. Figure 1 shows energy supplies and energy flows for Kitkatla. The two major components of the study were an assessment of the potential for energy conservation, and a detailed assessment of the wind power potential to reduce oil use.

Analyses of energy saving options available to the community are detailed in the report. Briefly, these are:

- energy management techniques costing little or nothing to implement;
- cost-effective reinsulation and building improvements to reduce energy use. A detailed table of measures showing costs and savings was developed and is presented in Section 4.3;
- water heating and heating system improvements; and
- electrical generation by load matching and generator sequencing.

Figure 2 is an energy savings options chart listing various approaches for reducing or replacing fuel oil in Kitkatla.

The energy saving priorities are to reduce oil use - for heat and for electricity. As in other diesel generator communities, it is important to recognize that the real cost of electricity is not paid by the local residents, hence the incentive to conserve is not as great as it should be.

Alternative energy resources for Kitkatla were evaluated: wind, wood, solar, small hydro and others. A detailed wind energy resource assessment was made involving a wind speed measurement program and a comparison with four nearby wind stations - Bonilla, Lawyer, Lucy and Triple Islands. Long term wind availability was determined and used in evaluating four

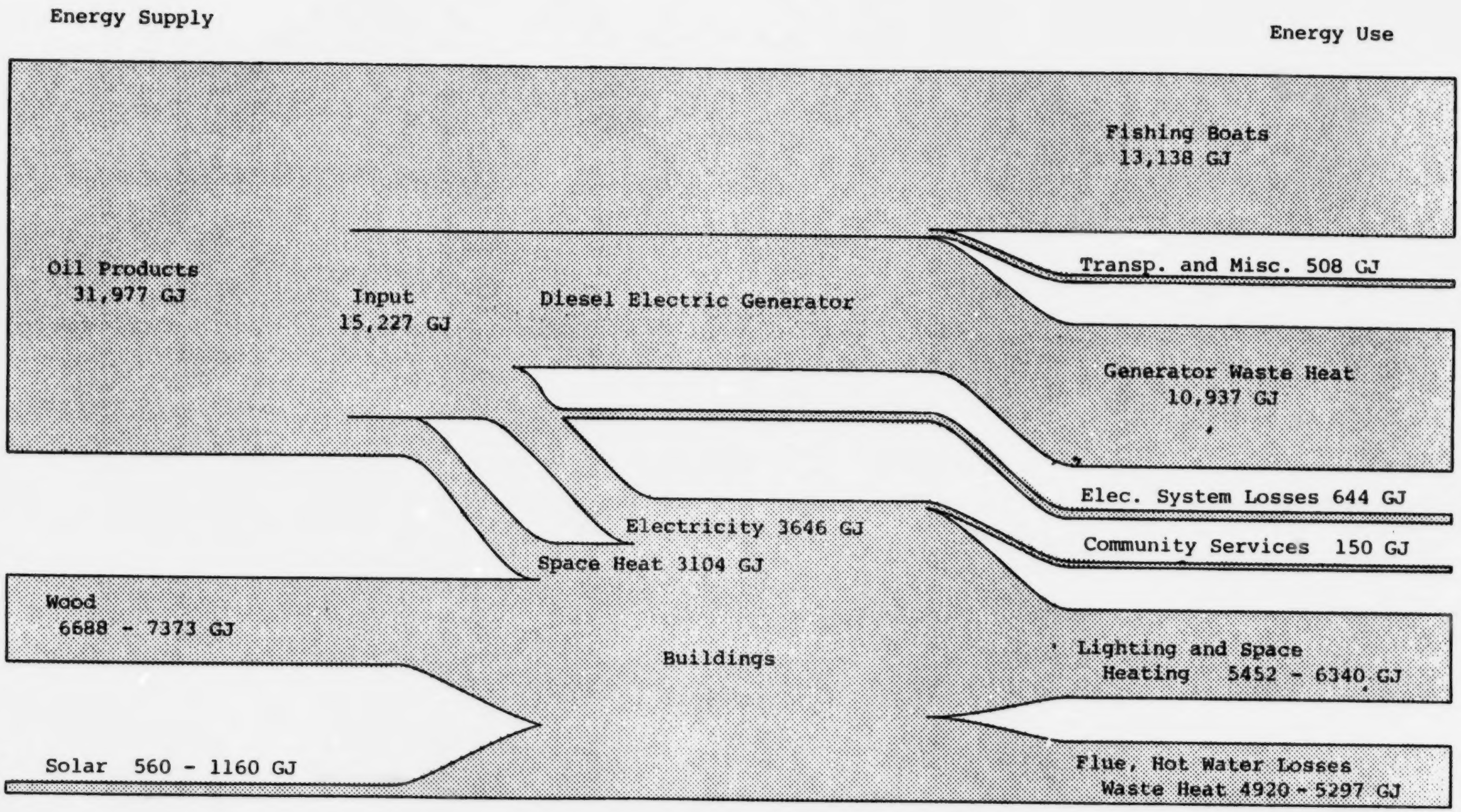
Energy Supply
Energy Use
Oil Products 31,977 GJ
Input 15,227 GJ
Diesel Electric Generator
Electricity 3646 GJ
Space Heat 3104 GJ
Wood 6688 - 7373 GJ
Solar 560 - 1160 GJ
Buildings
Fishing Boats 13,138 GJ
Transp. and Misc. 508 GJ
Generator Waste Heat 10,937 GJ
Elec. System Losses 644 GJ
Community Services 150 GJ
Lighting and Space Heating 5452 - 6340 GJ
Flue, Hot Water Losses Waste Heat 4920 - 5297 GJ

Figure 1. Energy Supplies and Energy Flows for Kitkatla Community

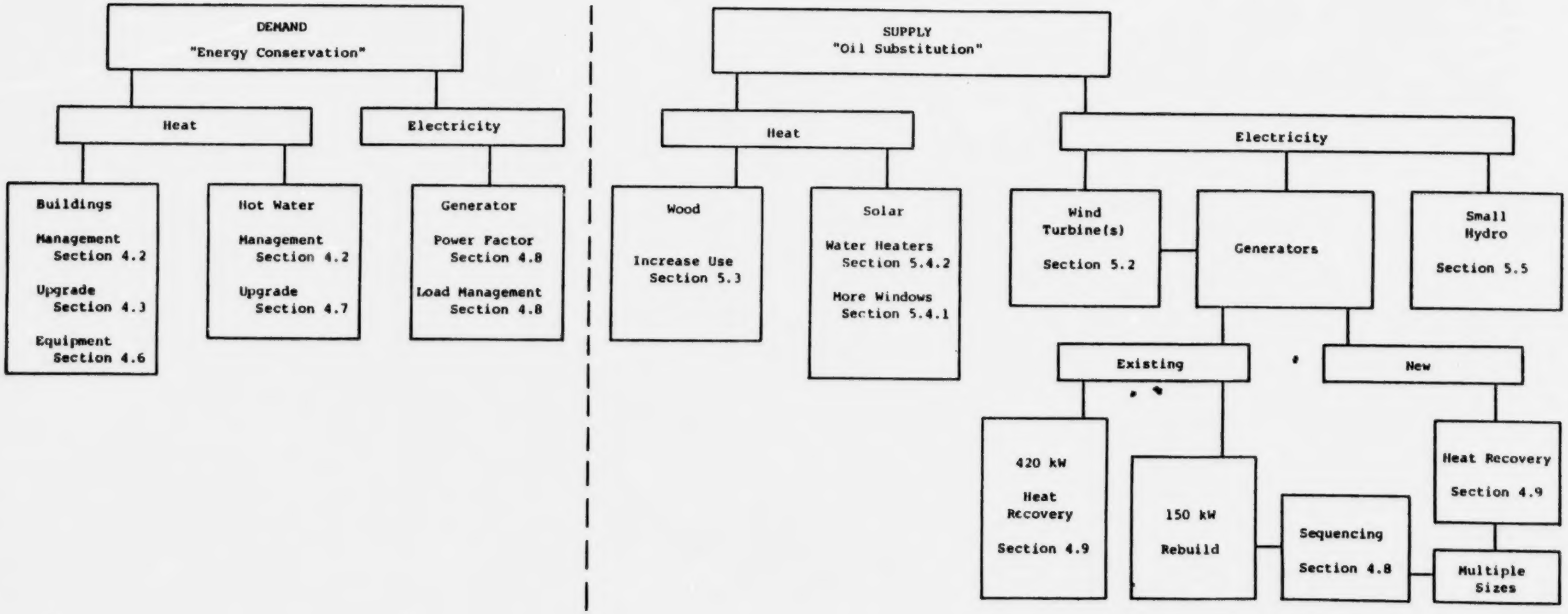
DEMAND
"Energy Conservation"
Heat
Electricity
Buildings
Management Section 4.2
Upgrade Section 4.3
Equipment Section 4.6
Hot Water
Management Section 4.2
Upgrade Section 4.7
Generator
Power Factor Section 4.8
Load Management Section 4.8
SUPPLY
"Oil Substitution"
Heat
Electricity
Wood
Increase Use Section 5.3
Solar
Water Heaters Section 5.4.2
More Windows Section 5.4.1
Wind Turbine(s)
Section 5.2
Generators
Small Hydro
Section 5.5
Existing
New
420 kW
Heat Recovery
Section 4.9
150 kW
Rebuild
Sequencing
Section 4.8
Heat Recovery
Section 4.9
Multiple Sizes

Figure 2. Energy Savings Options Chart for Kitkatla Community with Report Section Number References.

types of wind turbines. The best option could produce electricity at $ .14/kWh, and would be cost-effective in displacing fuel from the diesel generator. Total cost was estimated to be $170,000, saving $30,000 worth of fuel annually. Detailed feasibility and system design are recommended. Additional wind speed monitoring on a lower ridge closer to the village is also recommended to optimize wind potential and installed system costs.

Wood presently contributes between 25% and 27% of the non-commercial energy requirements. Wood has displaced 74% to 81% of potential oil use for residential heating purposes. Solar presently contributes between 8% and 16% of space heating. At present solar system prices, solar domestic water heaters are not cost-effective for homeowners because they pay less than the real cost of electricity. It is cost-competitive (15 to 20 year payback) for the utility or diesel operator to invest in solar water heaters to displace electricity used to heat water.

A preliminary analysis showed that a small hydro site on a nearby island may be able to replace present diesel generation needs cost-competitively. Projected capital costs were $1.65 million, saving $160,000 worth of fuel per year. Further assessment work should be undertaken in this regard. An inventory of other alternative resources was made; none were perceived to be both technically and economically feasible in the near future.

In conclusion, substantial fuel savings are possible. Energy conservation measures are available in conjunction with financial assistance for home reinsulation. For renewable resources, two options emerged to reduce generator fuel use:

- a lower-cost lower-savings wind energy project - with an estimated cost of $170,000 providing fuel savings of $30,000 per year; and
- a greater-cost greater-savings small hydro system - with a preliminary estimated cost of $1.65 million providing fuel savings of $160,000 per year.

WIND/DIESEL POWER FEASIBILITY STUDY
MUD RIVER, ONTARIO

Executive Summary

This study was undertaken by Doug Townsend and fellow residents of Mud River, Ontario to determine the feasibility of using wind power, supplemented by diesel fuel, to create electricity for the community.

Mud River is in the Thunder Bay District, just north of Lake Nipigon on the Pikitigushi River, 28 miles east of Armstrong. It is predominantly a native community with a population of 27. Since the community has no electricity, it depends on candles and kerosene for light. Heating and cooking needs are met by burning wood.

Winds at the nearby community of Armstrong, Ontario have been measured by Environment Canada at an average speed of 11.9 km/hr. Average winds of about 12 km/hr. are generally considered the minimum for a wind-based electrical energy system. Since winds at Mud River seemed to him to be stronger than those at Armstrong, Doug Townsend believed that a wind energy system might be feasible at Mud River.

A series of problems arose following the September 1983 commencement of the study. These difficulties prevented the installation of the wind measurement equipment, and thus wind readings, during the time of the study agreement. As a result, it is not possible to determine the feasibility of a hybrid wind/diesel energy system at Mud River.

The anticipated power requirements of the community were evaluated, however, and are described in the study. Current power requirements in Mud River are minimal. The community uses kerosene lamps for lighting and wood for space heating. Other than two small privately-owned generators, the community has no electricity. With the availability of community power, households would use several appliances: refrigerators, fluorescent lights, televisions and/or stereos, washing machines and assorted power tools. The study showed that, if electricity were available, the estimated monthly power requirement per household would be 65 kWh; the estimated monthly community power demand would be 647 kWh.

Wind measurement equipment was loaned to the community by the National Research Council of Canada (NRC). Unfortunately, prior to the March 31, 1985 completion of the study, NRC's wind program was cancelled and the recording equipment had to be returned. Determined to monitor the wind at Mud River, the community purchased a wind monitoring device from a firm in Vermont. Due to delays in delivery of the unit, the community was unable to take wind readings before the completion date of the study. The community intends to carry out wind testing and data analysis, however, and has offered to provide interested parties with its findings.

This study was undertaken with a financial contribution from the Remote Community Demonstration Program of Energy, Mines and Resources Canada (EMR).

SITE STUDY FOR WINDMILLS TO PRODUCE ELECTRICITY ON LES ILES DE LA MADELEINE, QUÉBEC

Executive Summary

L'Institut de recherche d'Hydro Québec (IREQ) has been interested in wind energy since 1975. In cooperation with National Research Council Canada and the Matapédia region of Hydro-Québec, IREQ now operates one experimental windmill on les Iles de la Madeleine, an area of both high winds and high electricity costs.

Several studies have been done on the feasibility of installing large windmills in the area. A 1982 IREQ study on the Canadian DAF-500 vertical axis windmill found that a 3 MW windfarm located near the experimental windmill would not produce electricity at a cost less than the value of the saved diesel generator fuel.

Convinced that other scenarios might show wind to be an economical source of power, IREQ undertook this 1984 study. Following a desk survey of six sites in the Grosse Ile area, two were chosen for further study. A 10m tower containing two anenometers and associated equipment was erected at each of the two sites. Wind direction and speed were measured for an average of one minute, six times an hour for six weeks. Similar measurements were also taken at the beach site of the experimental windmill, about 23 km south.

Both Grosse Ile sites had wind speeds approximately 10-20% higher than those at the experimental site on the beach. It is assumed that wind speeds at the very top of Grosse Ile would be slightly higher. Since the power of wind is proportional to the cube of its speed, a 10% increase in wind speed translates into an available power gain of approximately 33%.

Information from Hydro-Québec shows that the cost of power from the current diesel generator is $74/MWh. The experimental windmill theoretically produces 1143 MWh/year at a cost of $102/MWh. With wind speed increased by 10% and 20%, power production and costs are estimated to be, respectively, 1521 MWh at $77.40/MWh and 1975 MWh at $59.60/MWh.

In conclusion, to be feasible the DAF-500 needs 12% more wind than is available at the experimental site on the beach. It seems to be possible to identify sites on les Iles de la Madeleine which meet these criteria and thus which make wind energy feasible.

The study recommended that feasibility study be undertaken on the installation of windmills to produce energy.

This study was conducted by l'Institut de recherche d'Hydro-Québec with a contribution from the Remote Community Demonstration Program of Energy, Mines and Resources Canada.

FEASIBILITY STUDY OF SMALL WIND TURBINES
FOR DOMESTIC HEATING
ON LES ILES DE LA MADELEINE, QUEBEC

Les Iles de la Madeleine are buffetted by strong persistant winds and high electrical energy costs. As a result, l'Agente de développement économique local des Iles de la Madeleine (ADELIM) decided to evaluate the technical and economic feasibility of using small wind turbines to produce electricity for domestic heating on the islands.

The study was conducted for ADELIM by Roche Ltée, with a contribution from the Remote Community Demonstration Program of Energy, Mines and Resources Canada. Hydro-Québec, which supplies the power used on the islands, provided considerable advice, especially in the economic analysis.

The first stage of the study involved a technical and economic prefeasibility analysis of wind turbines under three scenarios: individual residences, groups of houses, and public and commercial buildings.

For each scenario, energy demand was determined. Then different types of wind turbines were studied to see which types could satisfy the demand. A number of wind turbines of varying power were selected and evaluated for their production of energy. They were then assessed for their net present value, internal rate of return and payback period. Scenarios I and II yielded promising results; since scenario III did not, it was dropped.

The second stage of the study, pursued for scenarios I and II, consisted of:
- an analysis of wind conditions on the island;
- an analysis of climatic factors which could influence the operation and maintenance of wind turbines;
- a listing of types of wind turbines and their technical specifications;
- a comparative evaluation of wind turbines in terms of energy produced by each machine under each scenario;
- a comparative analysis of systems to store energy;
- an analysis of the appropriate use of the energy produced by wind;
- an evaluation of the costs associated with the selected systems;
- an economic and financial feasibility analysis, taking into account technical specifications;
- a discussion of possible sources of financial assistance for such a project.

Requests to manufacturers resulted in information on many installed turbines. These were assessed on various criteria, including problems related to operation. Twenty-three machines were considered technically worthwhile, subject to field tests. The machines were generally from companies whose experience in the field is, if not lengthy, at least extensive, and which have many machines in operation.

Revenues and costs were projected for the two scenarios and net cash flows estimated. Revenues (or, more accurately, savings) are derived from two sources:

- the avoided diesel fuel cost, i.e., the litres of diesel fuel saved multiplied by the cost of a litre of fuel, with the fuel cost increased by inflation; and
- the maintenance savings realized from the less frequent operation of the diesel plant (a saving of about 2¢/kWh).

Nineteen of the 23 wind turbines were found economically feasible. Net present values ranged from $4,000 (scenario I) to $95,000 (scenario II). Rates of return, using current dollars, were estimated to range from 16.7% (scenario I) to 43% (scenario II). Assumptions underlying the economic analysis were:

- project life: 20 years
- base year: 1985
- planning period: 1985-2004 (20 years including the first year of the project)
- residual value of equipment in year 2004: $0
- discount rate: 13%
- interest rate: 10%
- inflation rate: 4.2%
- operating costs: increasing at a rate of 5.1% annually.
- price of a litre of petroleum: 27¢ in 1985, increased by inflation for the rest of the planning period

A sensitivity analysis to determine net present values under various conditions showed:

- changes in the inflation rate only marginally affected the economic performance of the project;
- changes in the interest rate, discount rate and operating costs moderately affected the economic performance, but without rendering the project economically infeasible;
- changes in wind turbine price, petroleum price, availability of turbine, and wind conditions moderately affected the economic performance and could render the project infeasible. (Availability of turbine refers to the percentage of time the turbine is in good enough condition to operate regardless of wind conditions).

As a result, the analysis was re-done, using different assumptions. The new net present value was $5,700, with a rate of return of 17%.

Assumptions (using Hydro-Québec's inflation and discount rates) were:

- inflation rate: 6.2%
- interest rate: 11.5%
- discount rate: 12.5%
- operating costs: 6.2%
- price of wind turbine: unchanged
- availability factor: 0.9%
- wind factor: 1.0%
- wind turbine: 10kW AEROWATT, made in France, producing 50,000 kWh/yr at 100% availability
- rate of increase in the price of petroleum:

1986	2.61%
1987	-0.93%
1988	1.63%
1989-2004	6.92%

In conclusion, the use of wind to generate electricity on les Iles de la Madeleine is technically and economically feasible for individual residences and for groups of homes. Since economic performance is so dependent on particular site conditions, a demonstration project would be in order to confirm the findings of this study.

Principal Performance indicators for scenario I - individual residences
(most probable scenario created with most recent data and forecasts)
(assuming connection to Hydro-Québec's grid)

Wind Turbine	Net Present Value (in 1985 $)	Internal Rate of Return (%)	Payback Period (In Years)
Jacobs-10 kW	-	-	-
Extrawatt-10 kW	(2,492)	-	-
Enertech-5 kW	(5,411)	-	-
Aerowatt-10 kW	4,225	16.72	5.91

Principal performance indicators for scenario II - groups of homes

Windmill	Net Present Value ($)	Internal Rate of Return (%)	Payback Period (Years)
1. Enertech-25 kW	-	-	-
2. Enertech-40 kW	11,392	15.75	6.21
3. Enertech-60 kW	28,810	19.32	5.22
4. North Wind Power-14 kW	-	-	-
5. ESI-54 kW	22,534	16.67	5.92
6. ESI-180 kW	82,308	18.57	5.40
7. Micon-22 kW	689	13.61	6.97
8. Micon-60 kW	52,032	27.40	3.78
9. Micon-110 kW	92,209	32.24	3.23
10. Vestas-55 kW L	63,680	36.16	2.88
11. -55 kW TC	60,459	33.47	3.11
12. -75 kW L	56,590	30.70	3.38
13. -75 kW TC	54,007	29.20	3.56
14. -65 kW L	72,487	38.92	2.68
15. -65 kW TC	69,169	35.92	2.90
16. -90 kW TC	95,580	43.12	2.41
17. Bonus-55 kW L 18 M.	9,407	15.33	6.33
18. Bonus-55 kW L 24 M.	9,284	15.19	6.38
19. Bonus-65 kW	53,487	23.93	4.31
20. Windmatics-55 kW L	62,468	28.52	3.64
21. -55 kW TC	55,984	25.71	4.02
22. -80 kW L	90,002	31.85	3.27
23. -80 kW TC	82,517	29.22	3.56

L Lattice tower
TC Closed tubular construction tower

EXECUTIVE SUMMARY

WIND ENERGY CONVERSION POTENTIAL OF REMOTE COMMUNITIES ON THE LABRADOR COAST

Approximately 79 communities in Newfoundland and Labrador are served by grid - isolated diesel generation systems. This study, commissioned by Energy, Mines and Resources Canada in November 1984, was to carry out a preliminary assessment of potential wind energy conversion system* sites and to identify suitable wind turbine installation for each of the potential sites in 14 communities on the Labrador coast which meet the criteria of the Remote Community Demonstration Program. These communities are Nain, Davis Inlet, Postville, Makkovik, Rigolet, Paradise River, Cartwright, Black Tickle, Charlottetown, William's Harbour, Port Hope Simpson, Saint Lewis, Mary's Harbour and L'Anse au Loup.

The study generally comprised three components:

.1 Collection, organization and evaluation of secondary source data.

.2 Matrix evaluation, site descriptions and selection of best sites.

.3 Technical review and selection of WECS machines.

The Site Assessment Methodology developed for the South Coast Wind Study**as well as data on wind turbines and wind intergration experience accumulated in carrying out the South Coast Study has been utilized extensively in the preparation of this supplementary report.

The site assessment methodology basically consisted of evaluating each of the 14 communities using a weighted matrix technique. The weighting categories being:

Windfield
Topography
Safety
Icing
Soils and Geology
Equipment and Skill Availability
Access
Social Impacts
Land Acquisition
Demonstration Visibility
Electro Magnetic Interference
Connecting Distance
Minimum System Demand

The assessment and evaluation of the 14 communities, carried out as a desk study, identified six communities as having a site with potential to support a WECS installation, with the following weightings:

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* In future references, abbreviated to: WECS

** This study, entitled "Wind Energy Conversion System, South Coast Region of Newfoundland, Prefeasibility Study" was prepared for Newfoundland and Labrador Hydro with a contribution from the Remote Community Demonstration Program of Energy, Mines and Resources Canada (RCDP report number: RCDP/PDCE-45), Dec. 19

Cartwright	115
L'Anse au Loup	115
Makkovik	105
Saint Lewis	105
Nain	85
Paradise River	80

The selection of WECS machines for each site was based upon the technical feasibility of the respective diesel generator systems to support a contribution from a wind turbine generator considering two modes of operaton: ie. with and without special load control features.

The wind turbines were selected from the list of machines identified through the South Coast Wind Study from a total of 46 parameters in the following categories:

- General
- Wind Speed
- Guarantee
- Physical Constraints
- Experience
- Costs

The WECS selected for each site are as follows:

Uncontrolled System

Nain

Maximum rating for WECS - 11 kW.

WECS Selected	Max. Power	Weighting
Enertech	5.3 kW	9280 pts

Paradise River

Maximum rating for WECS - 5 kW.

WECS Selected	Max. Power	Weighting
Enertech	5.3 kW	9280 pts

EXECUTIVE SUMMARY (Cont'd)

Uncontrolled System (Cont'd)

Cartwright

Maximum rating for WECS - 68 kW.

WECS Selected	Max. Power	Weighting
Enertech	44 kW	12375 pts
Moerup	65 kW	11091 pts
Daf-Indal	52 kW	11028 pts
Howden	60 kW	10925 pts

Saint Lewis

Maximum rating for WECS - 20 kW.

WECS Selected	Max. Power	Weighting
Northwind	16 kW	11016 pts
Windtech	20 kW	8137 pts

L'Anse An Loup

Maximum rating for WECS - 140 kW.

WECS Selected	Max. Power	Weighting
Windmaster	125 kW	10486 pts
Polymarin	100 kW	8834 pts
Adecon	125 kW	8175 pts

Controlled System

Nain

Maximum rating for WECS - 224 kW.

WECS Selected	Max. Power	Weighting
Howden	200 kW	11147 pts
Windmaster	215 kW	10437 pts

EXECUTIVE SUMMARY (Cont'd)

Controlled System (Cont'd)

Makkovik

Maximum rating for WECS - 148 kW.

WECS Selected	Max. Power	Weighting
Moreup	65 kW	11091 pts
Howden	100 kW	10925 pts
Windmaster	125 kW	10436 pts
Vesta	78 kW	10437 pts
Wintech	80 kW	9003 pts
Polymarin	100 kW	8839 pts
Adecon	125 kW	8175 pts

Paradise River

Maximum rating for WECS - 41 kW.

WECS Selected	Max. Power	Weighting
Enertech	27 kW	11413 pts
Man	33 kW	10490 pts
Wintech	20 kW	8137 pts
Extrawatt	30 kW	6095 pts

Cartwright

Maximum rating for WECS - 272 kW.

WECS Selected	Max. Power	Weighting
Howden	200 kW	11147 pts
Windmaster	215 kW	10437 pts

Saint Lewis

Maximum rating for WECS - 143 kW.

WECS Selected	Max. Power	Weighting
Moerup	65 kW	11091 pts
Howden	100 kW	10925 pts
Windmaster	125 kW	10486 pts
Vesta	78 kW	10437 pts
Wintech	80 kW	9003 pts
Polymarin	100 kW	8639 pts
Adecon	125 kW	8175 pts

EXECUTIVE SUMMARY (Cont'd)

Controlled System (Cont'd)

L'Anse Au Loup

Maximum rating for WECS - 968 kW.

WECS Selected	Max. Power	Weighting
Howden	333 kW	10925 pts
Carter	280 kW	10887 pts
Daf-Indal	522 kW	10198 pts
FDO Stork	300 kW	8489 pts

ASSESSMENT OF WIND ENERGY POTENTIAL, ST. ANTHONY, NFLD.

EXECUTIVE SUMMARY

The Town of St. Anthony contracted Fenco Newfoundland Limited to carry out a preliminary analysis of the wind energy potential within a 40km radius of the Town. The study was made possible by a financial contribution to the town from the Remote Community Demonstration Program (RCDP) of Energy, Mines and Resources Canada.

The study's objective was to select three sites, from an initial selection, that show the highest potential for wind energy conversion. The "Assessment Methodology for a Preliminary Selection of Wind Energy Conversion System Sites in Remote Communities",* provided by Energy, Mines and Resources Canada, formed the basis of the site selection procedure. Points were awarded for each of the fifteen (15) items in the Decision Matrix, as outlined in the methodology, and totalled to determine the best locations.

The initial task of the study was to carry out a preliminary assessment of the region. This involved gathering all available background information and mapping for the St. Anthony area. An initial selection of sites was made by considering windfield obstructions, site access, transmission line connection distance, and existing structures. Aerial photographs were obtained for each of these sites. All items of the Decision Matrix that did not require a field investigation were evaluated.

Once the preliminary assessment was completed, a field trip and site investigation was undertaken. This involved visiting each of the initial sites to obtain all necessary field information. The location of roads and transmission lines were confirmed while enroute to the sites. Photographs were taken for each location to assist in site

* (See page viii)

descriptions. Snow cover during the visit made some visual observations difficult. With this field information, the remainder of the Decision Matrix could be evaluated.

Once all items in the matrix had been evaluated, point scores for each site were totalled. The four communities that showed the highest potential are as follows:

Site 10	Cape Norman	155 pts
Site 9	Cook's Harbour	150 pts
Site 3a	Cremaillere Hill, St. Anthony	145 pts
Site 7	L'anse aux Meadows	130 pts

The final site selection involved final comments on the top four sites and any other information that may have been relevant to the final site selection for the purpose of wind monitoring. L'anse aux Meadows, the fourth choice, was eliminated from the selection due to its lengthy connection distance to three phase transmission lines, and its close proximity to a National Historic Site. Cape Norman is closer to transmission lines than Cook's Harbour, but it is not closer to three phase power, which may prove to be an asset. Finally, if the hills to the northwest of St. Anthony do not obstruct the winds to Cremaillere Hill, then this site will have to be re-evaluated.

The major conclusions and recommendations are summarized below:

1. The Assessment Methodology has been primarily developed for a remote community site assessment, not for an area of interconnected communities.

2. More consideration should be given to sites showing high average wind speed, where data is available.

3. Equipment and Skills Availability, and Social Impacts are not as important in site selection as the other items, thus point weightings seem high.

4. Access, as specified in the Assessment Methodology, only applies to remote communities. It was rewritten in this study.

5. If acquisition is economically unfeasible, a site should be eliminated rather than awarded 0 points.

6. The connection distance item should consider whether transmission lines are single phase or three phase.

7. The possibility of a wind farm should be investigated at each site.

8. Surface roughness and environmental impacts should be included in the assessment methodology.

9. The usefulness of the Community Questionnaire is uncertain at best. It was eliminated from this study.

Note: This report covers the first part of a study to assess wind potential in the St. Anthony area. Monitoring of wind speed, direction, etc. at the most promising site (determined by this part 1 study) is to take place for 12 months after April 1, 1985.

* Developed as part of a prefeasibility study entitled "Wind Energy Conversion System, South Coast Region of Newfoundland" by ShawMont Newfoundland Ltd. for Newfoundland and Labrador Hydro. The study was financed with a contribution from the Remote Community Demonstration Program of Energy, Mines and Resources Canada.

WIND ENERGY CONVERSION SYSTEM SOUTH COAST REGION OF NEWFOUNDLAND
PREFEASIBILITY STUDY

EXECUTIVE SUMMARY

Approximately 79 communities in Newfoundland and Labrador are served by grid-isolated diesel generation systems. This study, commissioned by Newfoundland and Labrador Hydro in May 1984, was for a prefeasibility analysis of installing wind energy conversion systems (WECS) in 12 of these remote communities: Petites, La Poile, Grand Bruit, Burgeo, Ramea, Grey River, Francois, McCallum, Rencontre East, Petit Forte, Southeast Bight and Monkstown.

The study was made possible by a contribution to Newfoundland and Labrador Hydro from the Remote Community Demonstration Program of Energy, Mines and Resources Canada. The consultant was ShawMont Newfoundland Limited.

The study's objectives were to select wind sites, evaluate machines and examine the technical and economic feasibility of wind generation on these sites.

The study generally comprised three components, each one of which had its own specific objectives and deliverables. These components are:

1. Site Assessment Methodology
2. WECS Evaluation/Selection
3. Prefeasibility Analysis

These are summarized in the following sections:

1. Site Assessment Methodology

This essentially involved the development, testing and refinement of a site assessment methodology document to provide guidelines and procedures for the evaluation of remote communities in Newfoundland and Labrador for WECS potential. Although the procedure was applied to only the South Coast communities during this study, it was developed such that it is applicable to the province as a whole. The objective of this phase of the work was to derive a methodology that would permit disqualification of sites which have no potential and priorization of sites, which appear to have potential, for further analysis.

Once developed, the procedure was tested, first as a desk study and then in the field, on the twelve South Coast communities in an effort to assess and refine the methodology and to select the three or four best communities for preliminary economic evaluations. The office and field results compared quite favourably, with the biggest discrepancies being with the access, connection distance, and topography criteria, and these were subsequently modified to accommodate the differences. The three communities which showed the most potential, and which were subsequently chosen for further analysis, were Burgeo, Monkstown and La Poile.

2. WECS Evaluation/Selection

The technical aspects of the study centered around the assessment and eventual selection of wind machines themselves. This phase of the work comprised: an extensive market review of Wind Energy Conservsion Systems, development of an evaluation/selection criteria for WECS relative to the parameters and constraints of remote communities in Newfoundland and Labrador, and application of this criteria to select the most suitable machines for operation on the South Coast of Newfoundland and throughout the provinces as a whole.

The market search identified some 119 WECS manufacturers who appeared to have potential with respect to this study, and these were subsequently contacted and information solicited. Concurrent with this process, an evaluation/selection procedure and criteria were developed which, by specific review and the application of weighting factors, would enable any machine to be readily assessed relative to Newfoundland remote community conditions (in fact, the criteria is general enough to evaluate and select machines for any application and circumstances with very little adjustment). Of the 44 responses received from the market solicitation, 26 were short-listed from preliminary evaluation for detailed assessment using the criteria. It was found, however, that the information received was not nearly complete enough to permit application of the criteria and these manufacturers had to be contacted again, and this time provided with a questionnaire containing all of the criterion items. This appears to have worked quite well as far as obtaining the required information is concerned. However, the responses to the questionnaire have been somewhat slow, and to facilitate the feasibility analysis a preliminary selection of WECS with ratings to match the three communities being studied was made from manufacturers with a proven field record for reliability and performance. Therefore, from the 26 manufacturers previously delineated the systems chosen for analysis were:

Burgeo -	Various combinations of Carter 250 kW machines.
La poile -	the 20 kW Windtech, 33 kW Aeroman and 25 kW Carter.
Monkstown -	the 25 kW Carter, 16 kW Northwind, 10 kW Jacobs, and 33 kW Aeroman.

EXECUTIVE SUMMARY (Cont'd)

3. Prefeasibility Analysis

The final phase of the study involved a technical and economic prefeasibility analysis of each of the three sites using the various alternative wind systems listed in the previous section. This analysis included the following main activities:

.1 Derivation of an economic model that would best facilitate the economic analysis. An in-house derived life cycle cost analysis computer program was used.

.2 A visit to each of the three selected communities to closely examine the site, obtain or confirm information, identify all constraints, and meet with diesel operators.

.3 Selection of alternative WECS systems for each site (outlined in previous section)

.4 Preliminary design of each site sufficient to develop concepts and permit derivation of cost estimates.

.5 Preparation of reasonably accurate capital cost estimates for each site.

.6 Inputing all cost and other financial data into the economic model and performing a detailed assessment of the outputs to determine the economic feasibility of each alternative for each of the three sites. Several of the alternatives chosen did materialize as being economically viable and these will be highlighted in the conclusions and recommendations which follow.

Due to the fact that annual average wind speed must be assumed for each site (from a study of data for Atmospheric Environment Service Stations along the South Coast) the overall economic assessments may not have been as accurate as possible in an absolute sense. They did, however, provide accurate cost estimates and a good measure of the economic range, as well as the relative economics between sites. This has indicated the potential viability of a WECS installation at the chosen sites and, thus, has formed the basis for assessing the viability of a demonstration project.

The major conclusions and recommendations emerging from this study are summarized below:

EXECUTIVE SUMMARY (Cont'd)

1. The Site Assessment weighting system provides a good indication of a site's potential, but it will never be absolute and a certain amount of subjective evaluation will be required.

2. Site visits verified that the desk study analysis of a site's potential, using the site assessment methodology, was reasonably accurate.

3. The final evaluation of the sites resulted in the following weighting:

Burgeo	140 pts
Ramea	113 pts
Monkstown	105 pts
La Poile	100 pts
Grand Bruit	90 pts

Burgeo, Monkstown and La Poile were selected for detailed feasibility analysis.

4. The use of MAST data is somewhat restrictive due to the limited data points available for regional analysis.

5. Because the community questionnaire responses are important to the preliminary evaluation, a telephone questionnaire should be developed in order to get community feedback early in the study.

6. At least two months lead time should be allowed to be sure of receiving aerial photographs of potential sites.

7. There appears to have been little research carried out on the long term effects of icing on the performance of WECS and the impact of this is largely uncertain. In this regard it is recommended that further work be initiated in this area to determine the relationships between number, duration and severity of icing storms and WECS operation and availability.

8. The extensive data and material collected for numerous WECS during this study will provide a valuable reference and basis for future WECS selection. The exercise of searching the WECS market need not be repeated for future studies.

9. In view of the difficulty in comparing and evaluating WECS from manufacturers' specifications and performance brochures, it is essential that all selected manufacturers be sent evaluation forms and explanations and requested to address each of the WECS evaluation/selection criteria.

EXECUTIVE SUMMARY (Cont'd)

10. All WECS whose total weighting total (from the evaluation/selection criteria) comes within 4000 points of the highest weighting should be given due consideration. Similiar to site evaluation, WECS weightings cannot be considered absolute and a certain amount of subjective evaluation is required.

11. The WECS evaluation/selection criteria and procedure were intended to provide a priorized list of WECS suitable for operation within remote communities of Newfoundland, and to this extent it was successful. It will not directly permit selection of specific WECS for specific sites.

12. The general formula for penetration into a grid-isolated diesel system appears to be: Load minus 40% operating diesel capacity to a maximum of 60% of load.

13. Detailed research and development is necessary to perfect a reliable control scheme which will permit high wind penetration into a diesel system while at the same time considering optimization techniques to minimize the dumping of excess energy. One very promising possibility which should be examined involves controlling variable pitch machines relative to load and generation.

14. The installation of two-250 kW Carter WECS at the Burgeo site is shown to be both technically and economically feasibile. The true payback is calculated to be 13.48 years.

15. With the exception of the 10 kW WECS Jacobs at Monkstown and the 20 kW Windtech at La Poile, all other alternatives chosen for these two sites were not technically feasibile at this time because special control schemes, i.e. dump loads, energy storage or pitch control, would be required to accommodate their relatively high penetrations.

16. From an economic point of view only, the 20 kW Windtech and 25 kW Carter analyzed at La Poile were not feasible while the 33 kW Aeroman would be marginally feasible with a true payback of 18.87 years.

17. For the Monkstown site, the 10 kW Jacobs and 16 kW Northwind alternatives were not economically feasible while the 25 kW Carter and 33 kW Aeroman are economically feasible with true paybacks of 19.32 years and 11.57 years respectively. The 33 kW Aeroman alternative at Monkstown turned out to be the most economically feasible of all systems studied.

EXECUTIVE SUMMARY (Cont'd)

18. The economic feasibility of WECS installation in the South Coast communities studied was not appreciably sensitive to variations in O & M costs and escalation, or salvage value. The feasibility was very sensitive, however, to changes in capital cost, fuel cost savings and associated escalation, and discount rate.

19. It is recommended that a demonstration project utilizing, initially, one-250 kW Carter machine (or equivalent) be carried out in Burgeo with a site monitoring program commencing very early in 1985.

ASSESSMENT OF WOOD-HEATING OPPORTUNITIES, FORT SMITH, N.W.T.

EXECUTIVE SUMMARY

Part I

The technical and economic feasibility of the installation of wood burning heating systems to serve selected commercial and government buildings in Fort Smith, is assessed in this project. The buildings include the planned new federal building, the RCMP detachment office, the GNWT regional headequarters building, the Winerack Building, the Pelican Rapids Inn motel, the Pinecrest Hotel, and the Hudson's Bay Store. These buildings are located in close proximity in the downtown core of Fort Smith and lie within a 125 m radius of the new federal building site. The MOT airport terminal building, flight service centre and the maintenance garage at the airport are also considered. The assessment considered the installation of individual, building-dedicated, wood fired hot water boiler systems. The concept of a single, centrally located wood fired low pressure steam boiler plant, serving all of the downtown core buildings heated above is also assessed. The concept proposed the delivery of steam to each client building through an underground flow line distribution system.

An examination of the building's current heating systems generally indicated that equipment is in reasonably good condition with no units imminently in need of replacement. All systems can be modified to accommodate steam energy from a remote central boiler plant, or hot water energy from a neighbouring wood boiler. All existing heating equipment is assumed to be retained for back-up or stand-by service. All buildings are currently heated by light fuel oil fired hot water boilers or hot air furnaces, except for the Winerack Building, now heated by electrical hot water boilers.

The owners were generally receptive to the notion of purchasing steam heat energy generated from a remote source, operated by a private entrepreneur. Reactions were negative, to mixed, regarding the purchase and operation of wood boiler units on their own.

The results of the economic assessment for individual building wood boilers are summarized in Table ES/1. The table indicates current heating costs; the equivalent number of air dried cords of wood fuel to meet the heating need; the capital costs required to install an appropriate wood boiler facility; the incremental cost savings realizable due to using wood fuel; and viability indicators. Payback period indicates the number of years of annual cost savings required to recover the original investment recognizing no time value for money. A discounted net present value calculation was used to provide a time-value-of-money weighted indication of project viability. The present value of annual cost savings, discounted at 7%, and net of the original capital project cost, for a 20 year project life time is indicated. On this basis, only the Pinecrest Hotel project and perhaps the federal building project are considered possibly viable. Effectiveness ratio provides a ranking of projects attractiveness adjusting NPV based on the required initial capital cost outlay. The highest ranked projects are the most effective use of investment funds.

The town core central wood boiler plant and distribution system, serving buildings #1 through #7 (Table ES/1) is estimated to cost $779,000. If energy is sold to consumers to just equal their current fuel costs, and the plant is staffed by two operators, the facility cannot generate enough revenue to meet its annual operating costs. If the labour and administrative costs can be significantly reduced by combining this operation with other proposed central wood boiler projects, a small profit on operations could be made, permitting a simple payback on initial capital investment in 14.7 years.

It is recommended that the Fitz-Smith Native Development Corporation (F/S NDC) does not proceed with the town core wood heating system unless the operation can be combined with another project as described, and non-refundable capital grants in excess of $450,000 can be secured. A secondary suggestion is made that the F/S NDC join forces with a reputable boiler systems vendor to promote the sale of individual wood boiler heating systems to the owners of the buildings where viability is indicated here. In this fashion, local contracting revenue and fuel wood supply revenue opportunities are created for the F/S NDC.

TABLE ES/1 VIABILITY OF COMMERCIAL WOOD BOILER SYSTEMS IN FORT SMITH

Building	(1) Current Heating Cost/ Annum	(2) Wood Fuel Reqt. (cords/ annum)	(3) Wood System Capital Cost	(4) Annual Operating Cost Savings	(5) Payback Period (3)/(4) (yrs.)	(6) Net Present Value of Savings *	(7) Effectiveness Ratio (6)/(3) *
1. Planned New Federal Building	$21,052	85	$98,050	$13,738	7.1	$ 47,490	.48
2. RCMP Detachment Office	8,233	33	94,500	4,495	21.0	-46,880	nil
3. GNWT Regional H/Q Building	24,460	99	113,700	16,236	7.0	58,304	.513
4. Winerack Building	15,000	42	102,400	10,606	9.6	9,960	.097
5. Pelican Rapids Inn	18,466	75	116,300	11,870	9.8	9,451	.081
6. Pinecrest Hotel	43,710	177	85,180	30,226	2.8	235,034	2.76
7. Hudson's Bay Store	19,999	81	129,300	5,486	23.6	-71,181	nil
8. MOT Maintenance Garage	11,369	46	97,100	6,700	14.5	-26,120	nil
9. MOT Terminal	6,400	26	89,770	3,107	28.9	-56,854	nil

*See Section 5.1 for assumptions

EXECUTIVE SUMMARY

Part 2

This project provides a technical description and economic viability analysis for a proposed central wood fired heating system to serve the space heating needs of a number of school buildings in Fort Smith, N.W.T. The major objectives of the work were: to develop a pipeline energy distribution system design to link the wood boiler plant to the various heating loads; to complete the overall design of the facility to the point where all technical issues were resolved; and to refine a capital cost estimate and economic viability analysis from previous studies based upon more precise engineering information in order to verify project economic viability.

The Fitz-Smith Native Development Corporation Ltd. (F/S NDC) is the proponent of the concept to sell heat energy to the GNWT - owners and operators of school buildings in Fort Smith. The buildings considered for heating from a centralized wood fuelled low pressure steam boiler plant are the J. B. Tyrrell Elementary School, P.W. Kaeser High School and adjoining Mt. Avens Women's Residence and Breynat Hall Men's Residence. To achieve the objectives of this work, the F/S NDC solicited proposals from a screened list of boiler system vendors for the supply, erection and start-up, on a turnkey basis, of a wood chip fired low pressure steam boiler plant. The plant consists of a single 7.0 million BTU/hr (2051 kw) wood chip fired boiler, a boiler building, a wood chip storage bin, and an automated wood fuel feed system. The F/S NDC also engaged the services of an engineering consultant to develop a technically viable design and specification for the pipeline steam energy distribution system.

The proposed distribution system is an underground, insulated piping arrangement based upon the RICWIL, INC. prefabricated insulated piping system concept. Three distribution loops are proposed, each one running from the boiler plant to one of the client building mechanical rooms. The piping system consists of prefabricated sections containing two steel pipes, each separately insulated, and the pair packaged into a common 10 gauge galvanized steel conduit. One line is used to convey steam to the client heating load. The second is used to return condensate from the client building to the wood boiler plant. Steam from the boiler plant is circulated directly through the building heating loops in two of the buildings. However, the steam energy is transferred to local circulating hot water loops via a heat exchanger in the third building, P.W. Kaeser High School.

The capital cost for the creation of the wood boiler facility was estimated to be $611,518, consisting of $250,000 for the boiler plant, $284,518 for the distribution system and 77,000 for other set up costs.

An operating scenario is proposed in which the operators hired for the boiler plant supervision activity also take on the responsibility to supervise the rest of the boilers in Fort Smith currently in GNWT-DPW custody. On that basis, an annual cost saving by adoption of the wood boiler system is estimated to be $121,362. This cost saving can be used to recover the original capital investment in 5.0 years.

F/S NDC is encouraged to enter a heat energy sales agreement in which the GNWT pays for energy at the prevailing energy cost for fuel oil in order to realize this economic payback period.

WOOD HEATING CONVERSION STUDY FOR RAE EDZO, N.W.T.

EXECUTIVE SUMMARY

The feasibility of converting the various building heating systems in Rae Edzo, N.W.T. to use wood as the primary fuel source is assessed in this project. The present fuel oil consumption represents a funds outflow from the community of approximately $450,000 per year. The use of wood fuel, harvested by local contractors and residents, represents a capture of a portion of this amount for the enhancement of the local economy. The use of wood fuel implies fossil fuel energy conservation, and is consistent with the principles of community self-sufficiency and living from the renewable resources of the land - concepts akin to the traditions of the predominantly Dogrib native population.

The project was initiated by a systematic examination of the major buildings and heating loads in the community. The present fuel consumption quantities were collected. The requirements and general suitability for the addition of wood burning heating equipment were assessed. In keeping with the requirements of the building owners or occupants, wood burning appliances were considered as additions to present oil fired heating equipment, with the oil heaters intended to remain in place for stand-by service.

Various types of wood burning appliances, most suitable for use in each of the candidate buildings, were identified. Depending on the specific building, hot water boilers, combination wood/oil furnaces, stand-alone wood furnaces, or add-on wood furnaces, were designated as the most suitable equipment for the application.

An economic analysis of the viability of many different buildings, fitted with appropriate wood heating systems, was undertaken. The analyses assembled capital costs for conversion, incremental operating costs, computed fuel wood requirements, fuel oil savings and net annual cost savings due to each conversion prospect. A community wood conversion plan was developed to guide the installation of wood burning equipment in viable cases, and the preparation of the community to accommodate the widespread use of wood fuel as a heat source. The conversion program

can be easily completed prior to 1988. Community issues and constraints relating to the adoption of wood fuel were investigated and reported.

The Rae Edzo community presently consumes approximately 1,100,000 litres of fuel oil per year and 1,250 cords of wood. The wood fuel estimate is a tenuous one based upon vague reports on community consumption habits. In the absence of wood conversion initiatives the volume of wood fuel used for heating and cooking purposes is expected to slightly drop in the future.

The installation of modern airtight wood stove equipment in residential dwellings is expected to cost typically $2,300 per installation. The savings possible from elimination of fuel oil expenditures permits recovery of this investment in four years.

The installation of forced air wood furnace equipment in typical residential settings costs on the order of $5,100 per installation. This investment is recovered typically in six years.

The installation of a self-contained wood boiler facility adjacent to the Jimmy Bruneau School, to substitute for the present fuel oil boiler operations is the most attractive large project in the community. Capital investment in the project may be recovered in less than 4.0 years. The facility is forecast to consume 350 cords of airdried jack pine wood chip fuel per year.

The Hudson's Bay Co. store, the Cottage Hospital, and a Hamlet owned equipment garage were also judged to be viable candidates for wood fired heating systems.

A number of central or district heating systems using a wood boiler facility were considered. A system serving 25 - 30 residences in Rae was forecast to not be viable. A system serving the Nishi Khon Centre and certain nearby buildings is marginally attractive, pending further consideration of the Nishi Khon Centre operation.

The most sensitive factor influencing project viability for wood conversion projects is the amount and cost of labour resources to tend the heating system. Automated fuel handling equipment and occasional daytime supervision only is generally necessary to preserve project economics.

The community is quite supportive toward a significant wood conversion program. No major community infrastructural development is required to sustain a large wood fuel heating program. Yellowknife tradesmen resources are likely required to assist with new equipment installation activities.

The successful conversion program is expected to increase community wood fuel use to about 2,500 cords/year in 1988. A total capital investment, from present to 1988, of $1,700,000 is forecast to install wood burning systems. 62,000 man-hours of work from present to 1988 is forecast to install and provide wood fuel for these systems, with an injection of $1,650,000 into the local and regional economy.

The conversion program is based on the conversion of all existing public housing units to the use of manually fed wood furnaces. The program includes the installation of similar wood furnaces in all new public and private residential dwellings. A number of commercial/institutional/municipal buildings are embodied in the conversion program, namely the J. Bruneau School, Cottage Hospital, Hudson's Bay Store, and Hamlet Garage.

A critical assumption to the viability calculations and the projections of economic impact is that one cord of wood fuel can substitute 616.6 litres of fuel oil. If wet wood fuel is consumed, or wood appliances are not properly maintained, relatively more wood fuel is required, reducing financial viability in the particular installations and causing an increase in the labour hours generated in wood harvesting.

A FUELWOOD STUDY FOR MACKENZIE REGION COMMUNITIES OF THE NORTHWEST TERRITORIES

EXECUTIVE SUMMMARY

This 1985 Biomass study was undertaken for the Northwest Territories Association of Municipalities, with the financial support of the Remote Community Demonstration Program of Energy, Mines and Resources Canada, and of the Economic Development Secretariat of the Government of the Northwest Territories.

The study continues initiatives begun in the 1982, 1983 and 1984 Building Inventory and Energy Use Surveys (BIEUS). This 1985 exercise looks more carefully at the potential for the use of wood fuels in space heating.

The study concludes that an organized fuel switch to wood from fuel oil could produce considerable opportunities for savings in space heating costs, and for the creation of badly-needed local employment in the 28 study communities. Due to a variety of government policies, oil is the predominant fuel type at the moment. A successful move to wood from oil would require free-market pricing, or a serious curtailment of present oil subsidy programs, in order to provide consumer incentive to seek the lower cost heating fuel alternative.

Initial research indicates that there is an abundant sustainable supply of wood fuel for virtually all communities and some potential for inter-community trade with the larger centres, such as Yellowknife. Efficient harvesting would require the creation of forestry inventories, forestry management plans, and some access routes.

In more specific terms, it is estimated that up to $17.5 million could be saved annually with full conversion to wood from fossil fuels. In addition, it is felt there would be significant but "intangible" benefits of community pride, control, and self-worth based upon the exploitation of a local renewable resource.

In terms of employment, it is estimated that full conversion to wood fuel would create up to 218,000 days of work across the study communities. This would equate to roughly 1,000 full-time jobs. Similarly, it is felt that the activity of using local wood fuels would create small business opportunities for entrepreneurial individuals or community groups.

This study was prepared for the Northwest Territories Association of Municipalities by Treeline Planning Services Ltd.

A FEASIBILITY STUDY FOR A WOOD-FIRED STEAM ENGINE/ GENERATOR SET FOR ELECTRICITY GENERATION AT FORT WARE, B.C.

SUMMARY

A. Introduction

The overall objective of this study was to assess the technoeconomic feasibility of a wood-fired steam power plant for supplying electricity in Fort Ware. Included in the study are estimates of electricity and heat requirements, a wood harvesting and forest management plan, designs of wood-fired power plants using a steam turbine and steam engine and an economic analyses of wood-fired plant options and a comparably sized diesel-fired plant. A steam engine was the main prime mover considered because of its robust construction, minimal requirement for maintenance, long service life and relative simplicity.

Fort Ware is a Reserve having a population of some 170 people which lies 440 km north northwest of Prince George on the north bank of the Finlay River. It is a remote community accessible by air year-round and by water when the waterways are ice-free and not blocked by floating debris. The community consists of some forty residences, a school and associated teachers' residences, a store, a church, a post office, a nursing clinic and miscellaneous other buildings.

B. Energy Requirements

Thermal energy is used in Fort Ware for space heating and domestic hot water. Buildings maintained by Indian and Northern Affairs (I & NA) and Health and Welfare Canada utilize diesel fuel for space heating and supplying domestic hot water. All other heated buildings in the community including native residences utilize wood for fuel.

Electricity is used in the school, teachers' residences, nursing clinic, store, Band office, church, Band storage shed and, temporarily, in two residences near one of the installed generator sets. Except for the residences mentioned above, none of the other residences in the community has access to electric power. Three diesel-fired generator systems are in place at Fort Ware, one being operated by the Band to supply a few community buildings (10 and 14 kW units), one being operated to supply the nursing clinic (two 12 kW unit) and the final and largest system being operated by I & NA to supply the school, teachers' residences and the domestic water supply and wash houses (three 44 kW units).

The peak electricity demand of the community over the long term, after allowance for diversity and including the requirements of a proposed community centre, was determined to be 176 kW. The annual power consumption of the community was estimated at 455,000 kWh.

Thermal loads which are candidates for supply using waste heat from a wood-fired power plant are the space heating and hot water loads of the school and the proposed community centre. The total peak thermal demand estimate for these buildings is 1.4 GJ/h. The average annual thermal energy consumption was estimated to be 1247 GJ for space heating and 128 GJ for domestic hot water.

C. Design of Wood-Fired Power Plant

A wood-fired power plant having a continuous rated output of 175 kW was chosen for analysis. A plant of this capacity appears to have the best fit to the design requirements:

- it would be able to satisfy the immediate electrical requirements of the community and the plant itself;
- it requires a wood supply that can be readily supplied from the surrounding forest using a minimum of mechanical equipment;
- it incorporates a boiler that, according to the Provincial Pressure Vessel Act, requires only one 4th Class power engineer to act as Chief Engineer, and three boiler operators as shift engineers.

The plant design with a steam engine has a net output to the community at rated conditions of 140 kW, the balance being consumed by the plant itself. The total annual power consumption of the community and the power plant equipment is 643,000 kWh.

Initially, a wood-fired power plant could satisfy all the electrical requirements of the community. In four to five years, as power demand increases, the total power demand may exceed the output capacity of the plant. Power demand in excess of the capacity of a wood-fired plant could be effectively satisfied by synchronously generating additional power with the existing diesel-fired power system operated by I & NA. This approach allows the wood-fired plant to operate as a base-load unit, and the diesel-fired plant to operate as a peak-load unit, which is consistent with the strengths of each type of equipment.

The base case wood-fired power plant consists of a storage area for cordwood, a chipper to produce the boiler fuel, a bin and conveying equipment, a fire-tube boiler designed with a working pressure of 1720 kPa and output of 0.7 kg/s, a steam engine/generator and air pollution control equipment. The boiler plant will operate under automatic control and requires operators for supervision and to take care of routine maintenance. Electricity is generated at 600V, 3 Ø, and is stepped up to 2400/4160V Wye for distribution to the community through overhead lines. Cooling water is needed to condense the exhaust steam from the steam engine for return to the boiler. This water is obtained from a well near the plant.

An alternate plant design was considered which utilized a steam turbine instead of a steam engine. All other parts of the plant were the same as in the base case design.

One other option that was considered allowed for recovery of waste heat from the base case plant to satisfy the thermal load of the school and community centre.

The wood-fired plant utilizes Aspen, Cottonwood and Birch harvested from Crown Forest in mature and immature stands of softwoods and hardwoods. The trees are cut and split in the woods to a size 1.2 m in length and 20 cm in maximum diameter and transported to a storage and drying area adjacent to the power plant. This fuel wood dries naturally to a moisture content of 20%, wet basis.

The annual fuel consumption of the plant, baed on a total power use of 643,000 kWh, is 1700 OD tonnes (1700 cords). This amount of fuel could be readily supplied from the surrounding Crown Forest within an 8 km radius of Fort Ware.

The base case plant converts 8.2% of the heating value of the fuel into electrical energy. The net efficiency of the plant, which allows for power consumed by the plant itself, is 6.6%. The overall efficiency of the base case power plant with heat recovery is 26.3% based on gross energy output.

The overall efficiency of the power plant with a steam turbine is 6.6%. In this case, the output of the plant is limited to 140 kW (gross) because the steam turbine has a lower efficiency than the steam engine under the steam conditions used.

D. Wood Fuel Harvesting and Management

The plan for the harvesting and management of the wood for the plant took into consideration the requirements of plant equipment, the abilities of Band members, training requirements, employment generated and costs.

A cursory examination of the resource present in the Crown Forest surrounding Fort Ware by the Ministry of Forests indicated that there is more than enough deciduous volumes for a wood-fired power plant. Application may be made to the Ministry for a Timber Sale licence, Forest Licence or Woodlot Licence to utilize the available resource. The most attractive form of tenure for the Band is the Timber Sale Licence, which is the least onerous of all tenures.

The recommended fuel harvesting program involves:

- harvesting from the Kwadacha West area initially, moving to the Kwadacha East and Finlay areas once hardwoods in the Kwadacha West are exhausted;

- utilizing skid trails to gain access to the forest and seven to eight cutters to fall trees and cut and split them to the required size;
- transport of the cordwood using two to four porters, two tractors and two wagons from the woods to the plant site.

Much of this recommended harvesting method will entail handwork. Addition of a loader to increase productivity could be considered once the harvesting crew has gained experience and there is justification for this increased mechanization.

Under the labour intensive plan recommended for initial implementation, the unit cost of cordwood delivered to the plant is \$56.21/OD tonne. Introduction of a loader results in a reduction of this cost to \$47.61/OD tonne. Overhead costs are additional to the above unit costs and vary depending on the quality of fuel harvested. At the estimated power consumption level, 1700 OD tonnes of wood are needed. The overhead costs in this case amount to \$20.53/OD tonne in the first-year and \$4.88/OD tonne in all subsequent years. Of course, the power consumption will increase from a base level in the first year of operation to the design value after a few years of operation, and the overhead costs must be adjusted accordingly.

E. Economic Analyses

Economic analyses were done for four plant designs using cost esimates made in this study. Three wood-fired plants were considered: a steam engine plant; a steam turbine plant; and a steam engine plant with heat recovery. For comparison purposes a diesel-fired plant was investigated which had a net power output similar to the steam engine based plant.

For all cases, the uniform power cost in 1984 dollars which yielded equality between present values of costs and revenues over the life of the plant was determined. Some of the more important results are summarized below using gross plant output to determine power cost:

DESIGN	SCENARIO	POWER COST (1984 Dollars/kWh)
Steam Engine	Base case	0.579
	- use a loader in and after the 2nd year - labour cost reduced 15% - capital cost reduced 10%	0.516
Steam Turbine Based Plant	Base case	0.659
Steam Engine Based Plant With Heat Recovery	Base Case	0.533
	- use a loader in and after the 2nd year - labour cost reduced 15% - capital cost reduced 10% - heat load increased to 2750 GJ by 1995	0.430
Diesel-Fired Plant	Base Case	0.426

The calculated power costs are based on gross output not net output. Much more power is required by a wood-fired power plant than a diesel-fired power plant, and, therefore, care must be exercised when referring to the power costs tabulated above. The least cost scenario tabulated above for a wood-fired power plant yields a power cost of \$0.608 kWh on the basis of power delivered to the community.

F. Conclusions and Recommendations

1. A wood-fired power plant having a continuous rated output of 175 kW is best suited to Fort Ware for reasons of scale of the fuel harvesting operation and the lesser requirements for training boiler operators. To achieve this power output while keeping the size of the boiler and the wood requirements of the plant within practical limits, a steam engine must be used as the prime mover for the generator.

   The boiler for this size of plant has a heating surface area of less than 100 m^2 and, therefore, could be operated under the control of a chief engineer having a Fourth Class certificate and three shift engineers having boiler operators certificates.

   The net power output of a steam engine based plant is 140-145 kW, less than the 175 kW rated output because of the power consumed by the plant itself. The net output is less than the estimated peak demand of the community (176 kW). Enlarging the size of the plant to satisfy the peak demand of the community is not attractive because this would necessitate use of one Third Class and three Fourth Class operating engineers, as well as an enlarged harvesting operation.

When the peak demand for power reaches the maximum capacity of the wood-fired plant, perhaps after four to five years of operation, the preferred means for satisfying the shortfall is by synchronously generating power using the existing diesel-fired power plant. This allows both plants to operate under conditions which best suit their respective operating characteristics.

2. A steam engine is preferable to a steam turbine as the prime mover for the plant because of its higher efficiency (lower steam requirement per unit of power output) at the steam conditions practical for the plant.

3. The most suitable location for a wood-fired power plant is north of the school complex on unoccupied land near the start of the Kwadacha trail. This site is on the eastern edge of the area selected for future community expansion and, therefore, would minimize the impact of the plant on residents. Wood would be delivered to the plant initially along the Kwadacha trail, which is away from dwellings and the school, thereby reducing safety hazards, and dust and noise nuisances. The plant site is close enough to the school and proposed community centre to justify piping of hot water to these locations for recovery of waste heat.

   The plant would occupy 0.77 ha of land in total.

4. The Crown Forests within an 8 km radius of Fort Ware are capable of supplying sufficient hardwoods for the plant for well in excess of 25 years of operation. The most suitable form of tenure by which the Band could utilize the wood resource is a Timber Sale Licence.

5. A labour intensive wood harvesting plan could be used by the Band to cut, split and deliver fuel for the plant. The plant developed in this study is compatible with the abilities of Band members and requies a minimum of mechanical equipment that would have to be operated and maintained. A one-year supply of fuel is kept at the plant to give time for air drying and prevent interruptions in fuel supply that might otherwise arise because of delays in the fuel harvesting operation.

6. Recruiting and training Band members to operate the power plant on a continuous basis is the part of the project most subject to failure. Recruiting and training Band members for the fuel harvesting operation is an achievable objective. Operators of the power plant must pass correspondence courses, obtain work experience and pass the Provincial examinations before being certified. With the support of the Band and involvement of the I & NA school teachers to assist Band members with their coursework, it is expected that a complete crew for the boiler plant could be trained. The training period for the boiler operators could extend beyond the eight and twelve months normally expected for boiler operators and Fourth Class Engineers, respectively.

7. Considering only the cost of producing electricity to serve the community, the most economical route is the use of a diesel-fired power plant. This approach would involve some local labour to supervise the engines and ensure they are properly maintained, but, at most, only one person, half time would be required. A diesel plant would be a major source of noise in the community.

8. Considering the need for employment, development of trade skills and reduction of oil consumption in Fort Ware, as well as the objective of minimizing the cost of producing power, use of a wood-fired power plant having a gross output of 175 kW and complete with a system for recovery of waste heat is recommended. Recovered heat should be used to supply the school and the proposed community centre.

9. Because of the potential for difficulties with recruiting, training and maintaining a work force for the fuel harvesting and plant operation tasks, Phase 1 of the project should be implemented first, preferably beginning in April 1985 or sooner, weather permitting. Phase 1, which could be completed in about three months, consists of a forest inventory, survey and clearing of a main haul road to the Kwadacha West area, and evaluation of results. A Forester/ Forest Technician and a superintendent from outside the community would be needed for Phase 1. Band members would assist the Forester and conduct the road surveying and clearing work. The trees felled would be cut and split to size, then delivered to the plant storage area. Harvesting of this timber should proceed using the described labour intensive program.

   An appraisal of progress and performance of the work program should be made in Phase 1 to otain information needed to assess whether implementation of Phase 2 of the project is feasible. The main concern is whether or not a reliable and functional work crew can be organized from the Band members for a long-term project. A further objective of Phase 1 of the work is to give the Band an opportunity to become familiar with the total project and its impact on the community, and contribute comments with regard to personnel requirements, project management and system design.

The approximate cost of Phase 1 of the project may be itemized as follows:

Consultant Forester	$14,000
Superintendent	6,000
Survey Assistants	1,500
Supervisor elect	2,000
Wood harvesting 500 OD tonnes @ $56.21/OD tonne	28,000
Consultant for Assessment and re-evaluation	15,000
Contingency	10,000
	$76,500

BIOMASS UTILIZATION STUDY
QUEEN CHARLOTTE ISLANDS

EXECUTIVE SUMMARY

The prime purpose of this study is to review the present means of supplying power to the B.C. Hydro system on the Queen Charlotte Islands, and to consider the potential and cost of supplying the present and future power requirements utilizing indigenous biomass resources. In May 1983, B.C. Hydro completed an in-house study "Queen Charlotte Islands Power Study - Preliminary Evaluation". The use of wood waste to fire a small thermal generating station, either through a conventional steam or wood gasification system, appeared to warrant further investigation.

With joint funding provided by Energy, Mines and Resources Canada, under the Remote Community Demonstration Program, B.C. Hydro carried out this prefeasibility level evaluation of the utilization of biomass for power generation on the Queen Charlotte Islands. This study is intended to assess the technical and economic feasibility of using indigenous biomass resources to displace oil for remote community power generation. The Queen Charlotte Islands are being used within B.C. Hydro to represent a typical remote community situation for alternative energy studies where power is presently supplied from diesel electric generating stations and integration is unlikely in the near future.

Diesel fuel is currently available on the Queen Charlotte Islands at a cost of 35.1¢/L (June 1984 dollars). It has been assumed that diesel fuel prices will increase at the rate of 1 percent per year (net of inflation) to 38.6¢/L in 1994/95. Thus, the representative total unit energy cost of diesel generation has been determined to be 155 mills/kW·h and 165 mills/kW·h for 1984/85 and 1994/95, respectively, in June 1984 Canadian dollars.

A wood waste availability and cost assessment was carried out by the Forest Engineering Research Institute of Canada (FERIC), in cooperation with MacMillan Bloedel (the main logging operator on Graham Island), to determine the amount of present and future biomass available as forest residues at the landings and roadsides, and as logging residue at the land sorts. Other sources of biomass fuel such as unmerchantable timber and driftwood have not been found to be suitable fuel sources due to the added cost of harvesting, or in the case of driftwood, the detrimental effects of sand and salt trapped in the wood. Peat has been considered qualitatively as a supplement to the wood residue fuel resource.

To attain a power demand sufficient to allow consideration of installation and operation of wood waste generated power, it is assumed that the new plant would service the majority of the electrical load on the Queen Charlotte Islands. This would require connection of the Sandspit and Masset generating systems by a 69 kV transmission line. It is assumed that the existing diesel generation stations would be retained as standby generating stations and used for peak load generation as the demand grows.

A conventional small biomass-fired thermal generating station concept has been developed. The new 10 MW centralized generating station is designed to supply all the near-term forecast load, exclusive of new industrial demand, for the Queen Charlotte Islands.

The thermal generating station design has been based on supplying 45.54 GW·h of electricity to meet a peak demand of 9.47 MW in 1994/95. The conventional wood-fired thermal generating station is commercially available and would be the most suitable plant for supplying reliable power at such a remote location. The base case plant is developed using two 5 MW packaged wood-fired boiler plants, although comparable plant capital costs were estimated for using a single 10 MW package or five 2 MW packages.

Basic plant design parameters, layout and offsite facilities were developed within B.C. Hydro. Particular design details, specifications, and cost estimates were provided by outside consultants.

A biomass gasification power generation status review is included as part of this study to determine a timeframe for commercial application of the technology. The wood gasification power generation technology is not expected to be commercially available to the same degree as the conventional steam boiler system for another 5 to 10 years. However, a conceptual design was prepared based on using the Imbert gasifier-gas engine system commercially available from Germany. The 10 MW station is based on 15 identical gasifier-engine generator power trains, rated at 685 kW each.

A detailed cost estimate was prepared based on a conventional thermal generating station at Ferguson Bay. Wood fuel preparation, site development and off-site facilities are included in the estimate. The cost estimate for the wood gasification power generation option was developed from the base case thermal station. An economic evaluation was carried out to compare the wood-fired thermal generating station options with the costs of the present diesel electric generating system. Although the unit energy costs for wood gasification power generation is not significantly higher than conventional thermal generation the technology is not sufficiently advanced nor reliable enough for consideration at this time.

No significant socio-economic or environmental impacts are expected from construction and operation of the thermal generating station. Environmental impacts from the thermal plant will be kept at or below the minimum standard levels for such plants. This will be achieved through good plant design and efficient operating procedures.

Construction activities will have some impacts on the terrestrial environment. However, since the site is adjacent to the existing logging and land sort operation these impacts will be minimal. Construction of the thermal plant will not disturb any known heritage sites. There is a midden of charcoal and crushed shells on the MacMillan Bloedel property nearby but this would not be affected.

A project of this size will certainly have some social and economic impacts, particularly in the Port Clements area. While the construction forces, and later the operating and maintenance crews, will not be large they will still represent a significant percentage increase in the present local population. The impact should be positive with some increased employment opportunities.

A computer program developed by B.C. Hydro was used for comparing the energy costs of the two wood-fired thermal power generation options. Since the cost of delivered wood waste to the station is the most sensitive variable in the operation of the thermal generating station, various fuel supply cost scenarios were tested.

The unit energy cost of power produced by a wood-fired thermal generating station was found to range from 112 mills/kW·h for low cost fuel at $31.10/ODt to 245 mills/kW·h for the high cost fuel at $153.46/ODt. The base case assumes that a blend of wood fuel could be made available, including some low grade pulp wood, at a cost of $100.40 resulting in a unit energy cost of 187 mills/kW·h (excluding additional transmission required to connect the Masset and Sandspit grids).

It was determined that the break even cost for wood waste, to match the cost of diesel generation at 165 mills/kW·h (1994/95), was $61.33/oven-dried tonne (ODt) (June 1984 Canadian dollars). The effect of a 20 percent grant (based on capital cost) for plant construction under the Forest Industry Renewable Energy (FIRE) Program would be to increase the break even wood fuel supply cost to $67.41/ODt. MacMillan Bloedel have indicated that low grade pulp wood could be supplied at about $100/ODt resulting in a blended fuel cost of $80/ODt. This cost is considered to be within a negotiable range for further evaluation and they are interested in further discussions regarding the wood fuel delivery.

A third party has indicated an interest in participating in a feasibility study and the detailed design of a 10 MW thermal generating station. They would also be interested in participating in the construction and operation of the station if it was found to be economically justified.

Based on this Study, it is recommended that:

1. a detailed station design and feasibility study be carried out for the siting of a 10 MW conventional wood-fired thermal generating station on the Queen Charlotte Islands;

2. a consultant capable of designing, construction and operating the station be solicited and participate in the design study.

THE FEASIBILITY OF ELECTRICITY PRODUCTION USING WOOD AS AN ENERGY SOURCE IN TROUT LAKE AND GARDEN CREEK, ALBERTA

EXECUTIVE SUMMARY

The study examines the feasibility of producing electricity from biomass using a steam boiler/steam (turbine) engine system for the communities of Trout Lake and Garden Creek.

The factors examined are as follows:

- Impact assessment on the communities.
- Biomass availability and alternate methods of harvesting the timber.
- Engineering analysis, system model, system efficiency, life cycle costing, operation and maintenance costs.
- Economic analysis of the steam boiler/steam engine (turbine) system and comparison to a comparable diesel generating system. Present value approach is used.
- Analysis of anticipated benefits, including increased employment, replacement of an oil dependent technology with a renewable source, and overall increase in the technical skills of the community.

Study conclusions and recommendations are the following:

- The quantity of Aspen/Poplar required for electrical conversion in a community consisting of two hundred people is very small and does not affect the environment adversely.
- A small sawmill steam boiler/steam engine system operating in a remote community with only two hundred inhabitants, with below average electrical power consumption, and no wood waste from a sawmill is not economically attractive. The very same system operating in a third world country would be economically attractive.
- Present value comparison between a diesel generating system vs. a small wood waste boiler/steam engine (turbine) system generating 150 kw of electricity had the following values and money allocation:

	Diesel System	Boiler/System Engine (Turbine) Chipping and Automatic Feed
Present Value	\$1,970,000.00	\$3,215,000.00
Manpower	5%	52%
Capital Cost:	8%	25%
Maintenance	6%	11%
Fuel Cost:	81%	12%

- Present value of the boiler steam engine (turbine) system using free biomass and no chipping was calculated to be \$2,126,000.00.

- The high manpower cost of the small boiler/system (turbine) engine system stems from the Provincial regulations to continuously supervise the steam boiler.

- The study also encompassed a benefit/cost analysis. The analysis concluded that the introduction of a biomass conversion system into Trout Lake would be viable if diesel fuel escalated in price at a rate of 3% above inflation, within the context of the assumptions in the report.

HEAT FROM WOOD
BRABANT LAKE, SASKATCHEWAN

Executive Summary

This study undertook to examine in detail current practices in generating energy from wood-fired appliances in the remote community of Brabant Lake, Saskatchewan (population 140; 27 homes), and to illustrate to residents of both Brabant and Southend, Saskatchewan how cost efficiency and safety might be improved.

> The study found that a broad range of circumstances over which residents have very little control, have profoundly influenced current energy consumption practices, and that the brevity of the experience with modern conversion technology poses some serious problems related to safety.

Problems noted include:

- the availability of well-seasoned wood will quickly diminish over the next 3 years, and will be replaced by fuel wood with a much higher moisture content.

- chimneys installed in the pre-1975 units are not adequate for continuous solid fuel use, and the potential for serious house fires occurring in these units over the next 5 years is high.

- there may have been too much concern for energy efficiency in the selection of wood-burning furnaces and space heaters for the remote communities with ready access to a fuel wood supply. Increasing efficiency of the combustion process, and extending the periods between refueling in the modern units, has been achieved by better controlling and directing the burn. The trade-off has been an increase in the potential for creosote build-up. The result may have been a higher incidence of chimney/house fires, and the related expense to the home owner and the public in order to conserve an inexpensive and readily available fuel.

- of more critical concern to the average resident in Brabant Lake than the cost of space heat energy, is the cost of water heat and cooking. Traditionally, one wood-fired unit has served all three purposes. In these "modern" homes, the "space" heater provides no surface for water heating or cooking. The result is high electrical service costs, particularly when the cost per kwh to the consumer ranges from 6 to 16 cents (depending on consumption).

- housing units with water pressure systems installed, which must be maintained at above freezing temperatures year round, are prohibitively expensive for low income families in remote communities where the cost of electrical power is high.

- the level of social assistance available through the D.I.A.N.D. program does not accommodate the occupants of units with water pressure systems, and subsequent higher electrical costs.

- some of the premises upon which "building standards" and design decisions affecting public housing programs for remote areas are being made should be re-examined with provision, for end user input on "life style" and liveability. Wood-fired cook stoves might be a partial solution to high electrical energy costs, but the existing housing designs will not readily accommodate them.

The report concludes that local councils and local residents can take a number of steps to enhance the safety of wood-heating practices. Among those steps are: proper operation and maintenance of equipment, and employment by councils of a part-time fire chief to ensure fire safety measures are undertaken. The report also concludes that electricity costs can be reduced if homeowners use wood fired cook stoves and water heaters and notes that some financial assistance is available to homeowners who might wish to upgrade their wood burning equipment. Finally, the authors say that the community meetings, at which information was shared, seemed to be well received. The report recommends that participatory workshops and seminars be held in other communities.

The study was done by Bell, Ahenakew and Associates and the Saskatchewan Research Council for the Brabant Lake Council with a contribution from the Remote Community Demonstration Program of Energy, Mines and Resources Canada.

REMOTE ONTARIO BIOMASS ASSESSMENT STUDY

EXECUTIVE SUMMARY

INTRODUCTION

There are 44* communities in northern Ontario that are considered to be remote regarding their sources of energy supply. Remote communities are defined as areas of population containing more than ten permanent households which are not connected to a main electrical grid. Fossil fuels are the primary source of energy supply for these communities. Diesel generators are presently used to produce electrical power for the majority of communities and others do not presently have electrical service. Fuel oil or wood are used for space heating in the homes and commercial and institutional buildings. Propane, naptha and kerosene are also used for cooking, heating and lighting.

The costs for purchasing and transporting fossil fuels and maintaining the generating systems in the communities which have electrical service are rapidly increasing, as is the demand for electrical power in the communities which do not presently have electrical service. Consequently this study was commissioned by the Ontario Ministry of Energy with the support of Energy Mines and Resources Canada.

This report contains a summary of the findings of a study to determine the potential and to estimate the cost of supplying wood and peat (muskeg) feedstock to biomass fuelled generating systems in selected remote northern Ontario communities.

The use of peat (muskeg) as biomass feedstock was investigated for one community and the use of wood biomass was investigated for four communities.

In this report biomass is defined as forest fibre (wood, bark, limbs, etc.) or peat (muskeg) which may be used for electrical energy and/or heat production.

The objectives of this study involved:

- Identification of the four remote communities that have the highest potentials for economically viable operation of biomass fuelled generating systems.
- Identification of the most appropriate method of biomass utilization (i.e. boiler/steam engine, boiler/turbine, gasifier/engine) for each of the study communities.
- Identification of the most appropriate methods of harvesting, processing and transporting biomass fuel to generating systems in each community.

Note:
* Under Energy Mines and Resources Canada's Remote Community

- Estimation of the cost per tonne* of biomass feedstock delivered to generating systems in each community.

- Estimation of the cost to install and operate biomass fuelled and diesel fuelled generating systems in each of the study communities.

COMMUNITY ASSESSMENTS

Evaluation of the 44** remote communities in northern Ontario resulted in identification of Armstrong, Fort Hope, Weagamow (Round Lake) and Gull Bay as those that have the highest potential for the economically viable operation of biomass fuelled generating systems. The locations of these communities are shown on Map 1.

Optimum Biomass Fuelled Generating Systems

The required electrical generating capacity and the optimum type of biomass fuelled generating system were identified for each community. These are indicated in Table 1.

TABLE 1

OPTIMUM BIOMASS FUELLED GENERATING SYSTEMS

COMMUNITY	ELECTRICAL GENERATING CAPACITY (kilowatt)	OPTIMUM BIOMASS FUELLED GENERATING SYSTEM
Armstrong	1,000	Option 1: two-500 kw water tube boiler/steam turbines Option 2: A gasifier/dual fuel engine could be installed when successful demonstration of the technology has been completed and if this is determined to be an economically competative generating system for this community.
Fort Hope	500	two-250 kw fire tube boiler/steam engines
Weagamow (Round Lake)	300	two-150 kw fire tube boiler/steam engines
Gull Bay	200	one-200 kw fire tube boiler/steam engine

Notes:

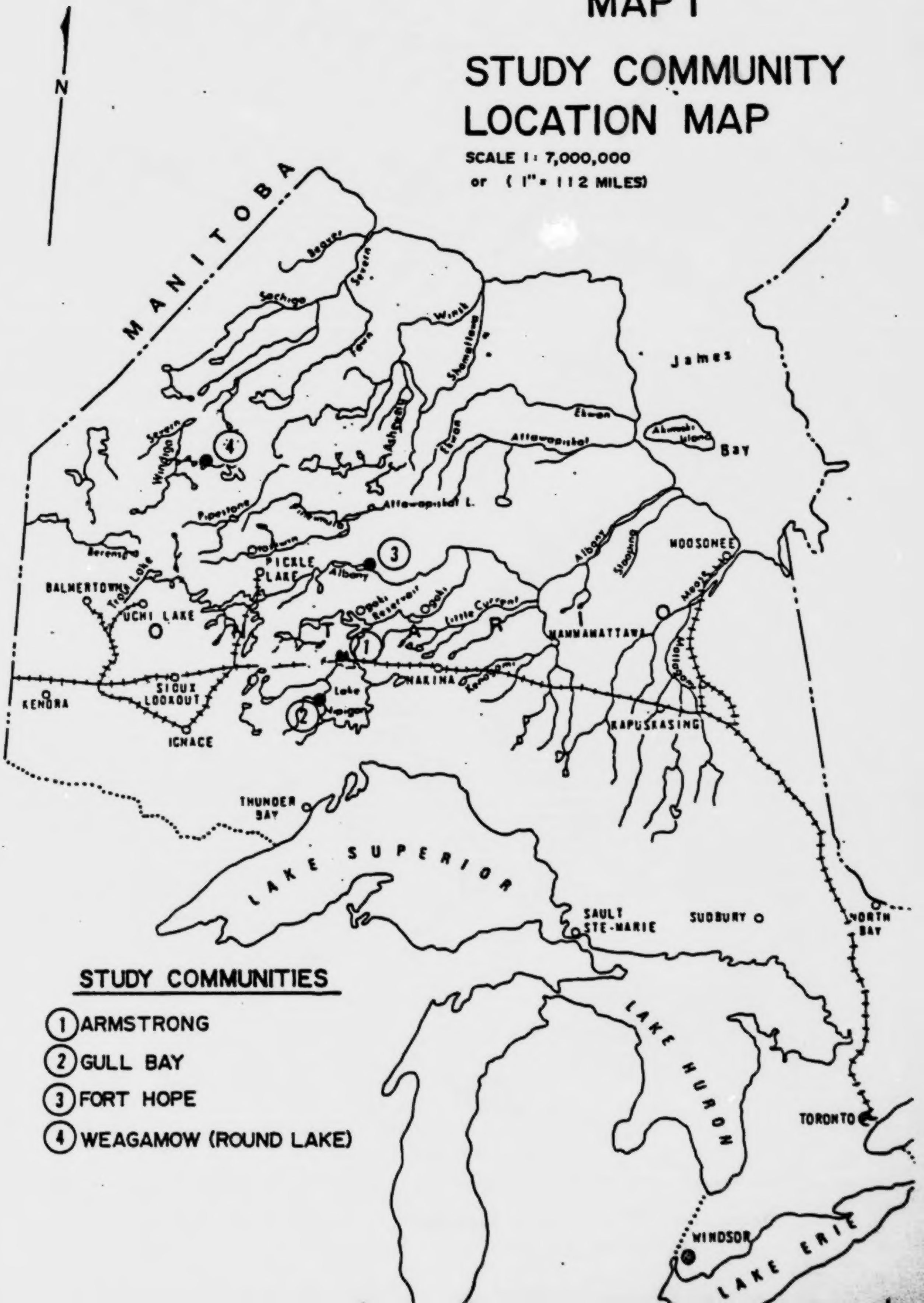
* 1 tonne = approximately 2240 lbs.

** Under Energy Mines and Resources Canada's Remote Community Demonstration Program 41 communities are considered remote.

MAP I

STUDY COMMUNITY LOCATION MAP

SCALE 1 : 7,000,000
or (1" = 112 MILES)


N
MANITOBA
Beaver
Severn
Sachigo
Fawn
Winisk
Shamattawa
James
Bay
Ekwan
Attawapiskat
Akimiski Island
Severn
Windigo
4
Asheweig
Pipestone
Attawapiskat L.
Berens
Trout Lake
BALMERTOWN
UCHI LAKE
PICKLE LAKE
Albany
3
MOOSONEE
Albany
Stooping
Ogoki Reservoir
Ogoki
Little Current
NAKINA
Kenogami
1
MAMMAMATTAWA
Moose
Mattagami
KENORA
SIOUX LOOKOUT
IGNACE
Lake Nipigon
2
KAPUSKASING
THUNDER BAY
LAKE SUPERIOR
SAULT STE-MARIE
SUDBURY
NORTH BAY
LAKE HURON
TORONTO
WINDSOR
LAKE ERIE

STUDY COMMUNITIES

① ARMSTRONG
② GULL BAY
③ FORT HOPE
④ WEAGAMOW (ROUND LAKE)

Sources of Biomass

The types and sources of biomass which are available to each of the study communities are listed in Table 2.

The supply of wood biomass to Armstrong, Fort Hope, Weagamow and Gull Bay is technically viable using available forest harvesting technology.

TABLE 2

SOURCES OF BIOMASS

COMMUNITY	TYPE OF BIOMASS	LOCATION
Armstrong	wood	- salvage of residues and residual unmerchantable tree species from existing logging operations in the Armstrong area (i.e. Armstrong Crown, Domtar Inc. and Great Lakes Forest products Management Units).
	peat	- peatland located north of Armstrong airport, contains sufficient quality and quantity of fuel grade peat to satisfy energy requirements of community for approximately 22 years. - harvesting of this peat is not considered practical using existing dry mining technology*.
Fort Hope	wood	- more than sufficient volume available in fire-killed and over mature birch and poplar stands within the Reserve.
Weagamow	wood	- more than sufficient volumes identified (Round Lake) in three harvesting areas, within the Reserve, Crown Land east of Reserve, Crown Land southeast of Weagamow (Round) Lake.
Gull Bay	wood	- salvage of residues and residual unmerchantable tree species, from existing logging operations of the Kiashke River Native Development Inc. (Band owned, timber licence No. 363200) and adjoining timber licences of Domtar Inc. Great lakes Forest Products and Abitibi Price Forest Products.

* Note: Harvesting of this fuel peat may be practical when wet mining techniques have been developed for Canadian application.

Armstrong is the only study community for which the supply of peat as a source of biomass fuel was investigated. The supply of fuel peat from the peatland north of the airport, which is the optimum peatland in the area, does not appear to be feasible using available dry mining techniques.

Biomass Requirements

The biomass requirements of Armstrong, Fort Hope and Gull Bay, which exhibit potential for significant community expansion and/or economic development, were estimated based on two scenarios. Scenario 1 assumes normal growth of the community and scenario 2 assumes full development of potential community expansion and/or economic development opportunities. This provides a range of anticipated biomass requirements.

The biomass requirements of Weagamow (Round Lake) are based on normal growth of the community.

The biomass requirements contained in Table 3 are for the year indicated.

TABLE 3

BIOMASS REQUIREMENTS

COMMUNITY	1984 (Tonnes)	1988 (Tonnes)	1993 (Tonnes)	1998 (Tonnes)	2003 (Tonnes)
Armstrong					
Wood Biomass					
Scenario 1	10,854	11,503	12,375	13,320	14,354
Scenario 2	20,405	21,405	23,027	24,663	26,444
Fort Hope					
Wood Biomass					
Scenario 1	3,906	4,141	4,439	4,770	5,145
Scenario 2	10,612	11,359	12,304	13,358	14,551
Weagamow					
Wood Biomass					
Scenario 1	4,974	5,311	5,704	6,092	6,470
Gull Bay					
Wood Biomass					
Scenario 1	3,817	4,033	4,191	4,358	4,601
Scenario 2	5,350	5,566	5,724	5,891	6,134

More than sufficient quantities of wood biomass are available to satisfy the requirements of all of the communities on a sustained yield basis.

Biomass Harvesting, Transportation and Processing Methods

The optimum method of supplying wood biomass to generating systems in Armstrong and Gull Bay would consist of the year round salvage of residues and unmerchantable hardwood species from existing logging operations. The biomass would be chipped at the logging sites and delivered to the generating systems in dump trucks.

The optimum method of supplying wood biomass in Fort Hope and Weagamow would consist of summer and fall felling of fire-killed stands and overmature poplar and birch stands. The logs would be bucked in 6 to 7 m (20 to 23 ft) lengths for transport by sleighs on winter roads. Logs in excess of 24 cm (10 in.) diameter would be used for fuelwood or lumber and the remainder would be chipped at the generating site for use as biomass fuel.

The supply of wood biomass as a source of fuel is technically viable at all of the study communities using available technology.

ECONOMIC AND SOCIAL CONSIDERATIONS

Biomass Fuel Cost Estimates

Table 4 contains estimates of the cost of wood biomass delivered to generating systems in each of the study communities. The wood biomass would be in chip form suitable for use as fuel.

TABLE 4

BIOMASS FUEL COST ESTIMATES

	ARMSTRONG	FORT HOPE	WEAGAMOW	GULL BAY
YEAR	wood biomass cost/green tonne ($)	wood biomass cost/green tonne ($)	wood biomass cost/green tonne ($)	wood biomass cost/green tonne ($)
1984	23.23	26.40	33.66	34.50
1988	29.04	33.00	42.08	43.13
1993	36.30	41.25	52.60	53.91
1998	45.38	51.56	65.75	67.39
2003	56.73	64.45	82.19	76.68

Note: Projections are based on an annual increase of 5%.
The costs shown are for the year indicated.

Biomass and Fuel Oil Cost Comparison

A comparison of the total estimated fuel oil and biomass costs and estimation of the net fuel savings, or losses (), which may result from use of biomass fuel in each community are contained in Table 5.

TABLE 5

BIOMASS AND FUEL OIL COST COMPARISON

COMMUNITY	YEAR	TOTAL FUEL OIL COST ($)	TOTAL BIOMASS FUEL COST	NET FUEL SAVINGS (losses) ($)
Armstrong				
Wood Biomass				
	1984	297,399	474,008	(176,609)
	2003	1,596,845	1,500,168	96,677
Fort Hope				
Wood Biomass				
	1984	303,187	280,157	23,030
	2003	1,714,026	937,812	776,214
Weagamow				
Wood Biomass				
	1984	87,138	167,425	(80,287)
	2003	452,046	531,769	(79,723)
Gull Bay				
Wood Biomass				
	1984	86,570	184,575	(98,005)
	2003	394,350	470,355	(76,005)

Note: Estimates of fuel requirements are based on full development of potential community expansion and economic opportunities.

Fuel oil cost projections are based on the 1984 cost of fuel oil in each community and the Ontario Ministry of Energy forecasts (Dec./83).

The costs shown are for the year indicated.

Estimates are listed for 1984, year five of the first five-year period during which use of biomass fuel appears to be more economical than fuel oil, and 2003.

Fort Hope is the only study community at which use of wood biomass as fuel for electrical generation would presently result in a fuel cost saving. In addition, potential exists for cogeneration for heating of buildings which may result in a saving of approximately $141,400 in displaced heating oil in 1984. This saving plus the potential $23,030 which may be saved in electrical generation results in a total savings of $164,430.

Generating Systems Capital Cost Comparison

The capital costs to install the optimum biomass fuelled and a comparable capacity diesel fuelled generating system in each of the communities were estimated. The generating capacity required, the optimum type of biomass fuelled generating system and the total cost and cost per kilowatt (kw) to install the biomass and diesel fuelled system are contained in Table 6.

TABLE 6

GENERATING SYSTEMS CAPITAL COST ESTIMATES

		OPTIMUM BIOMASS SYSTEM			DIESEL		ADDITIONAL COST FOR BIOMASS SYSTEMS	
COMMUNITY	ELECTRICAL CAPACITY (kw)	TYPE	COST/kw ($)	($000s)	COST/kw ($)	($000s)	COST/kw ($)	TOTAL ($000s)
Armstrong	1,000	steam turbine	4,900	4,900.0	1,729	1,729.0	3,171	3,171.0
Fort Hope	500	steam engine	A 3,850	1,925.6	2,128	1,060.0	1,722	856.6
			B 5,010	2,505.6	2,128	1,060.0	2,882	1,445.6
Weagamow	300	steam engine	4,610	1,383.5	2,660	978.0	1,950	585.0
Gull Bay	200	steam engine	4,880	976.0	2,925	585.0	1,955	391.0

Note: Cost estimates for the biomass systems include the costs of the power plant and generating system plus the costs of biomass harvesting; processing and transportation equipment and infrastructure which must be acquired to permit use of biomass as a fuel source.

Cost A for Fort Hope is for the biomass electrical generating system and excludes the cost of the cogeneration system. This is comparable to the cost of the systems at the other communities. Cost B is for the electrical generation and cogeneration systems.

For all of the study communities the cost to install a biomass fuelled generating system is greater than the cost to install a comparable capacity diesel generating system.

The additional cost per kilowatt (kw) to install the biomass as opposed to the diesel fuelled system is lower in Fort Hope than in any of the other study communities.

Generating Systems Operating and Maintenance Cost Estimates

The 1984 cost to operate and maintain the optimum biomass fuelled and comparable capacity diesel generating systems in each of the study communities were estimated. These estimates appear in Table 7.

TABLE 7

GENERATING SYSTEMS OPERATING AND MAINTENANCE COST ESTIMATES (1984)

		BIOMASS SYSTEM				DIESEL SYSTEM		
				OPERATION AND MAINTENANCE			OPERATION AND MAINTENANCE	
COMMUNITY	ELECTRICAL CAPACITY (kw)	TYPE	CAPITAL COST ($)	% CAPITAL COST	ANNUAL COST ($)	CAPITAL COST ($)	% CAPITAL COST	ANNUAL COST ($)
Armstrong	1,000	steam turbine	4,900,000	9	441,000	1,729,000	10	172,900
Fort Hope	500	steam engine	2,505,600	8	200,448	1,060,000	15	159,000
Weagamow	300	steam engine	1,383,500	8	110,680	798,000	13	103,000
Gull Bay	200	steam engine	976,000	7	68,320	585,000	12	70,200

Note: The percentages applied to capital costs take into account power plant staffing regulations and locations and size of systems.

The costs to operate and maintain the generating systems have been calculated as a percentage of the capital cost of the systems. The operation and maintenance percentage is generally lower for the biomass systems; however the capital cost is higher. As a result the operation and maintenance costs for the biomass systems are higher than those for the diesel systems in all of the study communities.

Employment Created

The number of people which may be employed and the wages created as a result of installation of a biomass fuelled generating system in each of the study communities are summarized in Table 8.

TABLE 8

EMPLOYMENT CREATED

COMMUNITY	BIOMASS SUPPLY	ENERGY PLANT STAFF	TOTAL	NUMBER OF PERSONS (YEARS)	WAGES
Armstrong	6	5	11	5.25	264,000
Fort Hope	14	5	19	13.3	227,600
Weagamow	14	5	19	14.0	302,360
Gull Bay	6	5	11	10.25	233,000

ADMINISTRATIVE FRAMEWORK

Table 9 contains a summary of the optimum administrative framework for supply of the biomass fuel and operation and maintenance of the generating systems at each of the study communities.

CONCLUSIONS

Of the 44* remote communities investigated, Fort Hope, Armstrong, Weagamow and Gull Bay, listed in order of descending potential, have the highest potentials for economically viable operation of biomass fuelled generating systems.

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* Note: Under Energy Mines and Resources Canada's Remote Community Demonstration Program 41 communities are considered remote.

TABLE 9

ADMINISTRATIVE FRAMEWORK

COMMUNITY	SUPPLY OF BIOMASS FUEL	OPERATION AND MAINTENANCE OF GENERATING SYSTEM
Armstrong	- supply by existing forest harvest operators i.e. Great Lakes Paper Company, Domtar Inc. under contract to the system operator.	- Ontario Hydro
Fort Hope	- Band form business to conduct forest harvesting operations.	- Existing Fort Hope Power Authority
Weagamow	- Band form business to supply biomass fuel under contract to the system operator.	- Ontario Hydro
Gull Bay	- Kiashke River Native Development Inc. - Band owned forest harvesting operation supply biomass fuel under contract to system operator.	- Ontario Hydro

Sufficient sources of wood biomass are available within economical haul distances of these communities to permit supply of wood biomass fuel on a sustained yield basis.

The supply of wood biomass to each of the study communities is technically viable using available technology.

With the exception of Armstrong, fire tube boiler/steam engines are the optimum type of biomass fuelled generating system for the study communities. At present, water tube boiler/steam turbines appear to be the optimum system for Armstrong. However, a gasifier/dual fuel engine could be installed when successful demonstration of the technology has been completed and if this system is determined to be economically competitive.

The 1984 cost per green tonne of wood biomass fuel delivered to generating systems in each of the study communities was estimated to be $23.23 in Armstrong, $26.40 in Fort Hope, $33.66 in Weagamow, and $34.50 in Gull Bay. Generally, the cost per tonne of biomass decreases with an increase in the volume required.

Fort Hope is the only study community for which use of biomass fuel presently appears to be economically advantageous over use of fuel oil. The use of biomass fuel in Armstrong appears to be advantageous between the years 1998 and 2003. The use of biomass fuel does not appear to be advantageous in Weagamow or Gull Bay within the 20 year projection period of this study.

For all of the study communities the cost to install biomass fuelled generating systems is greater than that to install comparable capacity diesel fuelled systems. The additional cost per kilowatt is lowest in Fort Hope.

With the exception of Gull Bay, the operation and maintenance costs for biomass fuelled generating systems would be greater than for diesel fuelled systems. In Gull Bay, the costs would be comparable.

The installation of biomass fuelled generating systems would result in the creation of between 11 and 19 jobs which would generate between $227,000 and $402,000 in wages annually in each of the study communities.

The Ontario Ministry of Energy conducted a computer analysis, of the economic data for each of the four detailed study communities to determine the payback periods for the biomass fuelled generating systems. In the case of Fort Hope the revenue consisted of the potential fuel oil savings resulting from cogeneration (i.e. electrical generation and space heating) and revenue from an integrated forest harvesting operation (i.e. lumber and fuelwood). The payback period was calculated to be three years. For Armstrong, Weagamow and Gull Bay the revenue consisted of the fuel oil savings for electrical generation only. Payback on biomass fuelled systems installed in these three communities is not anticipated within the 20 year projection period of this study. The employment and resultant wages which may be created for the community members were not taken into consideration in these analyses.

RECOMMENDATIONS

The primary objective of this study involved the determination of the cost of biomass fuel delivered to generating systems in the study communities. In addition, some of the related economic considerations have been evaluated at a prefeasibility level. Prior to installation of a biomass fuelled generating system, a community specific detailed economic feasibility study should be conducted. This study should include: evaluation of the employment and wages created; the revenue which may be generated through development of an integrated forest harvesting operation (i.e. biomass, fuelwood and lumber); and the effect on Unemployment Insurance Commission and welfare transfers.

The lack of a coordinated policy for the investigation, installation, operation and maintenance of alternative energy supply systems in remote communities creates a barrier to the use of these systems. The government agencies responsible for energy supply in these communities should cooperate in the development of such policies.

Policies should also be established for the provision of incentives to encourage communities to pursue the installation of alternative energy systems where these systems are determined to be economical. These incentives may be in the form of wage subsidies for employment created or reduced power rates or increased levels of electrical service.

The appropriateness and economical viability of using biomass fuelled generating systems in remote communities are dependent upon a number of factors. Some of these factors are: the existing population; economic development and physical structure of the community; the anticipated population growth and economic development; the potential for cogeneration; the availability and cost of biomass fuel; interest of the community members; future cost of diesel fuel; and development of biomass energy systems technology. It is necessary to evaluate these and other factors to determine the appropriateness and economical viability of biomass fuelled generating systems for a particular community. However, it appears as if use of biomass fuelled generating systems may presently be economical in Fort Hope and may become economical in Armstrong between the years 1998 and 2003. Evaluation of the previously mentioned criteria may result in identification of other communities which exhibit similar appropriatness and economical viability to Fort Hope and Armstrong.

FIREWOOD DEMAND AND SUPPLY STUDY
FOR EASTMAIN, WEMINDJI AND WASKAGANISH, QUEBEC

EXECUTIVE SUMMARY

Objectives

The Cree Regional Authority is trying to rationalize the use of firewood as an alternative source of energy for residential heating purposes in the communities of Waskaganish*, Eastmain and Wemindji.

The objective of this study is to provide the following information:

- assessment of the wood supply and wood demand in the three communities over the next thirty years;
- definition of the optimal exploitation strategies for wood;
- evaluation of the costs associated with various wood-oil utilization scenarios for residential heating purpose in order to recommend the optimal energy mix for each of the three communities.

Methodology

The maximum firewood demand is a function of the wood calorific value and the heating energy demand. The calorific value depends on the wood species and its humidity level. The heating energy demand is derived from the results of an energy audit of a representative sample of houses in the three communities. The energy audit results are then extrapolated over the next thirty years using the forecasts of the residential sector evolution.

Firewood supply is assessed through a standard and well accepted methodology used by forestry specialists. The objective is to define an area with an adequate forest potential to fulfill the heating energy needs of the residential sector of the three communities. The harvesting is planned as not to handicap the long term forest capital. Exploitation strategies are also studied in order to minimize the costs and to maximize the forest yield.

The wood supply operations are designed to be labor intensive so as to minimize the purchase of expensive equipment which would be underutilized.

A financial analysis completes the study. Seven heating scenarios including oil, wood and electricity heating are studied as to define the heating option which minimizes the cash outlays while taking into account the social impacts related to each scenario.

---

* Formerly known as Rupert House and Fort Rupert

The heating costs include fuel cost, purchase of heating equipment when necessary and maintenance cost. These costs are discounted to January 1st 1984, with a discount rate of 6%. This rate is expressed in real terms without inflation. All costs are in 1984 dollars.

Conclusion and recommendations

The energy audit indicates that the recent house models are energy efficient and the planned renovations should improve significantly the older houses energy consumption. The average room temperature is kept lower than the canadian average which means that people in these three communities consume less energy for a given outdoor temperature than the average Canadian. This conclusion is incorporated into the houses energy consumption evaluation.

The persons interviewed expressed their interest in having a dual energy system such as a wood-oil furnace. Wood is used to lower the heating costs and the oil furnace is used as a stand-by unit which starts working if the wood furnace is missing fuel (firewood). The manual feeding of the wood furnace is then no more considered as a problem.

The total energy demand in 1983 was 3 736 000 KWh, 1 463 000 KWh and 2 879 600 KWh for Waskaganish, Eastmain and Wemindji respectively. Energy demand projections are made for thirty years. This demand is then translated in wood demand.

This study indicates the existence of an adequate forest potential surrounding the three communities which can fulfill their heating needs for the next thirty years with acceptable ecological impacts. In Eastmain, the area including the sites where people traditionnally get firewood contains enough wood to satisfy their long term heating energy demand.

In Waskaganish and Wemindji, wood harvesting will be executed over a larger area. This is the consequence of their larger population and a weaker forest capital in the immediate surroundings. The maximum travel distance to harvest wood will be 20 km in Waskaganish and Wemindji.

The harvesting method suggested is labour intensive and uses snowmobiles and sleighs for the wood transportation. A communal approach is proposed as to ensure a controlled exploitation of the forest capital and to favour a larger utilization of wood as heating fuel.

The production cost of a large cord of wood will vary from 105$ to 125$ depending on the distance between the harvesting site and the community.

The present worth of the heating costs when only oil, wood or electricity is used are presented below:

TABLE I

PRESENT VALUES OF RESIDENTIAL HEATING

	100% oil	100% wood	100% electricity(1)
Waskaganish	6 217 000$	2 780 400$	13 825 600$(2)
Eastmain	2 271 700$	953 800$	-
Wemindji	4 815 200$	2 124 300$	-

Firewood reduces the heating costs by approximately 55% when compared to oil. Obviously, it is possible to combine various proportions of wood and oil, the annual costs increasing with the proportion of oil used. The purchase and maintenance costs have also to be increased since they imply the operation of two distinct furnaces.

Furthermore, woodchip technology may develop in a near future and prove to be a feasible option for northern remote communities. One of the major advantages of this process is its automatic feeding system which significantly eases the utilization of wood furnaces.

The all-electricity scenario for Waskaganish was the most expensive one with a present worth of 13,825,600$, which more than doubled the all-oil present worth.

Despite the low cost of the 100% wood scenario, the manual feeding of the furnace is considered as a major disadvantage that is no longer acceptable. A solution to this problem is the wood-oil furnace where oil is mainly used at the end of the night and when the house is not occupied. The 75% wood - 25% oil scenario is consequently recommended.

Every new houses as well as the renovated units should be equipped with a wood-oil furnace.

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1. Produced by a mini-hydroelectric power plant.
2. This includes a proportion of the construction costs.

It is suggested that an information program should be provided to the communities on wood heating use and maintenance to avoid hazards usually associated with wood systems. Energy, Mines and Resources, Canada has already developed a program on these topics and may be a good source of information on this subject.

Fire protection measures have to be looked at too. Since present services are linked to hydro-electric project developments in the region which are to be phased out, fire protection will not to be any longer available in a near future to the CREE communities.

It is suggested that fire protection services should be negotiated with federal and provincial governments so as to maintain them adequately.

The forest capital being limited, a proper management of this resource is required. Reforestation at these latitudes is risky and expensive. More detailed studies would be necessary before going any further in that direction. A rational utilization of the present woody resources will ensure long term firewood supply at low cost.

BIOMASS STUDY, CARTWRIGHT AND BLACK TICKLE, LABRADOR

EXECUTIVE SUMMARY

1. Objective and Methodology

This study was undertaken to assess the potential to increase the use of biomass fuel in the Communities of Cartwright and Black Tickle, and in this way, reduce consumption of imported oil. First the existing situation was investigated and forecasts were made for future developments assuming that no major infrastructural changes are made. Next infrastructural and organizational changes were recommended and their impact on the use of fuel wood investigated.

2.1 Residential Heating Fuel Demand

In both Cartwright and Black Tickle, biomass fuel (wood) already forms the largest category amongst domestic heating fuels. In Cartwright 85% of the homes use wood either exclusively or in combination with oil or electricity, in Black Tickle 61%. In Cartwright 70% of the people who currently burn wood, always burned wood; in Black Tickle 60% switched over in 1981 and 1982.

Most people in Cartwright who still burn oil at the moment do so because they have no physically able, unemployed person in the home who can get firewood, or because they live in Federally owned housing units and are not responsible for their heating cost. The last category has no incentive to conserve oil or to convert to biomass fuel.

In Black Tickle most people who burn oil at the moment do so because they have no physically able, unemployed person in the home, who can get firewood or because their wood supply is so far away (42 km average haul).

So, without major infrastructure changes, the saturation level has been reached in both communities and very few additional homeowners will convert from oil to wood. Actually, the reverse may be true, when distances to wood supplies continue to increase, and oil prices stabilize or drop, or when the local economy improves as a result of improvements in the fishery. When some or all of these things happen, some people will convert back to oil.

Fuel demands could also drop when homes are retrofitted or use more energy efficient stoves. Present insulation values are far below recommended standards, and a major effort should be made to educate the people about the benefits of retrofitting.

Finally, fuel demands could drop as a result of a shrinking of the population like is demonstrated in Cartwright, where the population dropped from 752 in 1971 to 580 in 1985. In Black Tickle, after a period of stagnation from 1976 - 1981, the community seems to be growing again slowly to a current population of 220.

The annual cost to heat a typical home in Cartwright and Black Tickle exclusively with oil, wood or electricity is tabulated below:

	Cartwright	Black Tickle
Oil heated home	$1,952.35	$4,280.00
Wood heated home, incl. labour cost	1,844.83	5,773.40
Wood heated home, excl. labour cost	683.23	3,050.68
Electrically heated home	2,510.97	4,325.55

From this table can be concluded that at the present hauling distance of 10 km for Cartwright, wood heating is still more economical than heating with oil or electricity, even when the cost of labour is taken into account at $4.00 per hour. Excluding the cost of labour, they can save on the average $1,270.00 per year on their annual heating bill by burning wood instead of oil.

In Black Tickle, because of the longer haul (42 km average), when the cost of labour is taken into account at $4.00 per hour, wood heating is the most expensive form of heat. When no value is placed on the labour component of getting firewood, wood is approximately $1,230.00 per year cheaper than oil. Obviously in Black Tickle, people get a very poor return for their effort, but may have no other choice, due to poor financial circumstances.

The typical cost for people in Cartwright and Black Tickle to get firewood and look after their wood heating system was found to be:

	Cartwright	Black Tickle
Direct Cost (gas and oil)	$ 36.54/cord	$ 86.83/cord
Indirect Cost (repairs, maintenance of snowmobile, komatik, saw, clothing, etc.)	41.10/cord	110.37/cord
Subtotal	$ 77.64/cord	$197.20/cord
Labour cost (@ $4.00 per hour)	132.00/cord	176.00/cord
Total cost	$209.64/cord	$373.20/cord

We found that wood could be shipped from Goose Bay to Cartwright or to Black Tickle F.O.B. dock for only about $72.00 per cord. So from a strictly economic viewpoint it would be better for people from both communities to import their wood from Goose Bay, than to cut it themselves and haul it in komatik* loads.

2.2 Commercial and Institutional Heating Fuel Demands

The commercial and institutional buildings in Cartwright and Black Tickle use mainly oil as heating fuel (83% of their combined net energy demand). Most premises in those categories are either not occupied 24 hours per day, or their occupants are full time employed and have no time to look after a wood heating system. Without major Government subsidies or other incentives, it will not be feasible for each of them to convert to wood on an individual basis.

2.3 Power Plant Fuel Demand

The largest consumers of petroleum based fuel in Cartwright and Black Tickle are the power plants, which consume respectively 67% and 63% of all oil burned in these communities (actual quantities are 630,430 litres in Cartwright and 339,790 litres in Black Tickle).

Acres Consulting Services Limited recently carried out a study to convert diesel power plants in Roddickton, Main Brook and Croque to biomass fuel. They found that only with the largest of the three, in Roddickton, conversion would be feasible. Because the Cartwright electrical demand is less than one quarter of the Roddickton diesel generated energy demand, and the Black Tickle demand is even less than the Main Brook electrical demand, it was considered not feasible for the Cartwright and Black Tickle power plants to convert to wood without significant Government subsidies.

*A komatik is a sledge

3. Impact of Government Incentives

Although the prospects for increased future use of fuel wood in Cartwright and Black Tickle are not very good, there are ways to promote the conversion from oil to wood. All of these require Government incentives to get set up, but could conceivably support themselves afterwards.

Most of these incentives are not economically feasible from an "off-oil" conversion perspective only, but because they could create considerable local employment, and could have social benefits, they may be attractive to Government from a combined socio-economic and employment viewpoint.

3.1 Methods to Increase Residential Fuel Wood Demand

Residential fuel wood demand in Cartwright and Black Tickle can be increased by lower cost and better availability. This can be accomplished by new infrastructure and by organization.

The infrastructure could be an access road for the Cartwright area and secure wood storage depots in both communities, which would facilitate the harvesting of wood in bulk during the fall. The depots would also be required if wood is imported from Goose Bay by coastal boat during the summer months.

Organizational requirements would be to set up the depots and access road construction & to try to get the private sector to run the depots. In case of lack of interest from the private sector, the Development Associations should initially manage the depots for one year, to prove their viability. After that period, they should again attempt to transfer them over to the private sector, by putting them up for bids.

Cost of a depot for 1150 cords in Cartwright is $35,000, and for a 400 cord depot in Black Tickle, $25,000. Cost of a 16 km access road towards Paradise River is estimated to be $800,000. Docks in Cartwright and Black Tickle are adequate to handle the unloading of fuel wood, especially if it is shipped in smaller quantities e.g. 100 cords each week on the regular coastal boats.

3.2 Methods to Increase Commercial and Institutional Fuel Wood Demand

The above mentioned infrastructure and organization need to be in place before any increases in the commercial and institutional demand can be expected. These sectors however, require something extra to convert from oil to wood. They require Government grants to defray part of the cost of converting from oil to wood, similar to the COSP* grants, but they will further require an "Energy Supply Agency" that will look after their heating systems on a day to day, and on a contract basis.

This, of course, can only be feasible if a large enough number of buildings participate, and is therefore out of the question for Black Tickle. In Cartwright, where the annual heating cost of these two sectors is $75,000, there appears to be some potential. Again, ideally a private sector firm should run the "Energy Supply Agency", however if no businesses or individuals are interested, the Development Association could run it for the first year to get it organized. After that year, it could be put up for bids, together with the fuel wood depots.

*COSP - Canada Oil Substitution Program

3.3 Methods to Increase Power Plant Fuel Wood Demand

The only way that Newfoundland and Labrador Hydro would convert its power plants in Cartwright from oil to wood, is if sufficient Government incentives are provided under employment creation programs, to make it feasible for the Utility Company to convert. Because there is no real wood supply in the Black Tickle area, it is highly unlikely that its power plant will be converted from oil to wood. Cartwright, because of its larger size and availability of wood, has the most potential.

4. Conclusions and Recommendations

From a strictly economic viewpoint it is cheaper to import wood from Goose Bay than to cut it locally in both Cartwright and Black Tickle. To encourage "off-oil" conversion alone, one should encourage therefore the shipping of wood from Goose Bay to both communities, by means of setting up fuel wood depots close to the docks. This is recommended for Black Tickle. From a socio-economic perspective, it would be better for the community of Cartwright if its local wood supply is made accessible for trucks, by means of construction of an access road. A new 16 km long access road in the general direction of Paradise River would open up enough wood resources to supply the fuel wood demand for Cartwright for the next 20 years.

Fuel wood depots will require management and organization, which ideally should be provided by the private sector. The Development Association should arrange for that right from the start, if at all possible, or otherwise after one year of operation, when all bugs have been ironed out and they have proven that they can be a viable operation.

To enhance conversion from oil to wood by the commercial and institutional sector, the Development Association should further arrange for an "Energy Supply Agency", again if possible, managed by the private sector. It would tie-in to the management of the fuel wood depot. With the above described infrastructural and organizational changes, approximately 270,000 litres of oil can be converted to wood per year.

Finally, the conversion would really have a large impact on Cartwright, if the power plant would be converted as well, with the help of Government incentives. Assuming that 75% of the energy demand of the Cartwright power plant would be provided by wood, this would reduce oil consumption in Cartwright an additional 470,000 litres per year.

BIOMASS FUEL UTILIZATION STUDY IN NORTHERN NEWFOUND AND COASTAL LABRADOR

EXECUTIVE SUMMARY

This study involved the review of the potential to convert commercial buildings to wood burning in three areas of coastal Labrador and Newfoundland as follows:

Region 1-Labrador Coast
Region 2-Labrador Straits
Region 3-Roddickton/Main Brook

A visit was made to each area to investigate the buildings conversion potential and the available wood resource of each area. A number of criteria were chosen and weighed by importance. Each building was scored and the region totals determined the best region. Region 1 was chosen as having the most potential. The main factors were cheaper wood and higher fuel prices.

The wood conversion was studied from the point of view of using wood chips and roundwood. It was determined that the economy of scale was not large enough to justify wood chipping and a heat storage solid wood burning unit was recommended.

An economic analysis of the payback periods revealed that paybacks of 5 to 11 years were realizable. Pay back periods are longer in Mary's Harbour and St. Lewis because of higher wood costs.

The three buildings offering the best conversion potential at this level of study are the Grenfell Hospital in Charlottetown, the Charlottetown Inn and the Grenfell Hospital in Port Hope Simpson. The Pentecostal School in Port Hope Simpson also shows a relatively short payback period, but the installation is probably too large for a demonstration project.

It is recommended that the three most likely buildings be investigated in more detail to determine final sizing and wood fuel requirements. The interest of the administration must be confirmed. When firm prices for wood fuel and for equipment, building additions and installation are obtained a final decision can be made.

The study also looked at the potential to ship firewood from Port Hope Simpson to communities on the coast of Labrador. The costs were found to be favourable and a trial was recommended for 1985.

THE POTENTIAL FOR ENERGY CONSERVATION AND FUELWOOD SUBSTITUTION IN REMOTE COMMUNITIES IN NEWFOUNDLAND AND LABRADOR

1.0 EXECUTIVE SUMMARY

The Remote Community Demonstration Program (RCDP) is a federal government initiative designed to promote the awareness and adoption of alternate energy and energy conservation technologies in remote communities. An overview study for Newfoundland and Labrador was prepared for the Newfoundland office of Energy, Mines and Resources Canada during the summer of 1983, and provided socio-economic profiles and technical assessments of the likely alternatives to oil for both space heating and electrical generation for eligible communities. As a result of this study, a number of gaps in the information base required to administer the RCDP Program in Newfoundland and Labrador were identified. Particularly significant was the inadequacy of the current data base to evaluate the potential for energy conservation and fuelwood substitution in remote communities of Newfoundland and Labrador. As a consequence, a proposal was submitted to the Newfoundland and Labrador Rural Development Council to undertake a study to identify and analyze the technical and economic factors affecting the potential for energy conservation and fuelwood substitution in communities throughout Newfoundland and Labrador eligible for the RCDP Program.

The present study had two major independent but interrelated components. The first component was designed to estimate the potential for energy conservation for the four regions defined as part of the overview study referenced above - Labrador, Northern, Central and Southern. The second component was designed to consolidate the existing fuelwood inventory base for each eligible community and estimate the potential for fuelwood substitution.

In order to estimate the potential for energy conservation it was determined that a representative sample survey of 400 households, 100 for each of the four regions, was required. The questionnaire contained information on housing characteristics, e.g. age, tenure, type, structure and size; socio-economic characteristics, e.g. age, income, education, employment status; energy consumption patterns and costs, e.g. primary and secondary heating sources; and energy conservation characteristics, e.g. levels and types of insulation; and related conservation variables, e.g. window glazing and weatherstripping. In order to utilize the information collected by the survey to estimate conservation potential, a methodology was developed which compared existing energy conservation practices in remote communities to the retrofit standards recommended by CMHC for existing residential buildings. This methodology essentially enabled the analyst to measure the existing heat loss from a home given present energy conservation practices, and to estimate the potential net reduction in heat loss which would occur should CMHC standards be implemented. Furthermore, given current energy consumption patterns and costs, the potential for energy conservation was translated into estimated energy and dollar savings.

The principal survey findings can be summarized as follows:

- The majority of homes in remote communities are owner-occupied, single detached dwellings that are either bungalows or two-storeys built after 1950.

- The majority of respondents in remote communities use wood as the principal heating fuel, i.e. 53%. Regionally this breaks down as follows: Labrador 64%; Northern - 56%; Central - 62%; and Southern - 29%.

- Ninety-four percent of respondents do not use any form of supplementary heating.

- Ninety-one percent of the respondents who use wood as their main heating source cut their own wood, and 91% of these obtain it within 20 miles of their homes.

- The estimated average annual consumption of oil for people using oil as the main heating source is 956 gallons. Regionally, this breaks down as follows: Labrador - 1181 gallons; Northern - 1026 gallons; Central - 1036 gallons; and Southern - 767 gallons.

- The estimated average annual consumption of fuelwood for people using wood as the main heating source is 11.1 cords. Regionally this breaks down as follows: Labrador - 16.2 cords; Northern - 9.3 cords; Central - 8.8 cords; and Southern - 8.2 cords.

- The socio-economic characteristics of respondents can be summarized as follows:

    - Gender - 55% male, 45% female.
    - Age - 59% between 25 and 44.
    - Occupation - 28% in primary, 38% in other, and 34% not in labour force.
    - Employment Status - 48% of respondents in labour force unemployed an average 5.5 months in past 12 months.
    - Education - 43% completed grade eight or less.
    - Income - Average total household income estimated to be $21,219.

- Conservation potential, i.e. the difference between existing building heat loss based on present energy conservation standards and the reductions in heat loss possible by upgrading to CMHC standards, is 72% for all regions. Regionally, this breaks down as follows: Labrador - 72%; Northern - 70%; Central - 73%; and Southern - 71%. Major areas for improvement are the ground floor and the attic and this is consistent throughout all regions.

- The estimated annual energy savings per household associated with this conservation potential is 136 million BTU's. Regionally, this breaks down as follows: Labrador - 186; Northern - 128; Central - 131; and Southern - 96.
- The estimated annual cost savings per household associated with this conservation potential is $899. Regionally, this breaks down as follows: Labrador - $1072; Northern - $858; Central $830; and Southern - $839.

In order to consolidate the existing fuelwood inventory data base as it pertains to remote communities, contact was made with the Provincial Department of Forest Resources and Lands to obtain the required mapping information. Throughout the process of collecting this information a number of important findings were made. Inventory mapping is completed for 18 management areas on the Island of Newfoundland; however, some of this information is dated from early 1960 and 1970 work. Little information is available on non-commercial timber stands and there is no detailed information on the percentage of inventoried forest which is now dead or dying as a result of the spruce budworm infestation. To further complicate the task of preparing fuelwood inventory calculations for the 77 communities identified under the RCDP Program, it has been determined that no forest inventory maps are completed or are planned for the entire south coast of the island portion of the province, and that only preliminary information is available for certain portions of Labrador.

Given the limitations on data availability it was only possible to do an analysis for eleven load centres encompassing 37 communities. This represents 48% of the total 77 communities identified as eligible under the RCDP Program.

In conducting the analysis of fuelwood availability a number of basic steps were followed. Using the 1:30,000 scale inventory maps for the island and 1:20,000 scale maps for Labrador, a detailed listing of the accessible timber stands was compiled. The stands selected were based on the criteria of using a 30 km radius envelope centred at the community under consideration. Timber stands 1.5 km on either side of roadways and waterways or within 1.5 km of the coastlines were considered to be accessible to the type of equipment normally used by individuals harvesting fuelwood. The area method was used to determine the allowable annual cut in hectares for each envelope.

For the community envelopes in the Newfoundland regions, a weighted average age was determined by multiplying the area of an age class by the age class midpoint. The average normal age as used by the Department of Forest Resources and Lands is 35 years. The allowable normal annual cut is found by dividing the total area regardless of age by 70 years, with the initial 20-year allowable cut being that found by multiplying the allowable normal annual cut by the ratio of the weighted average age to the average normal age.

In Labrador the age of the forest stands is not readily available. Therefore the allowable annual cut was found by dividing the total accessible area by 70 years.

Information on the average volume yields of forest areas by management unit was obtained. The data is available on computer printouts giving average volume yield per hectare by stand type for each management unit.

The areas by stand type obtained previously were multiplied by the appropriate volume yield and average yield obtained for each species and community envelope.

Of the eleven load centres under consideration, six have their reference community's envelope overlapped by other communities. In other words, the area of the 30 km radius envelope falls within areas that would come under pressure to supply fuelwood to other communities, some of which may be within the load centre, while others are outside.

In order to determine the significance of the sustainable yield from each of the envelopes, and the overlap influence, other information had to be determined, such as the percentage of current woodburning dwellings and the percent of the total heat currently being provided by wood for these dwellings.

The detailed calculations resulting from the above methodology enable the analyst to arrive at the Estimated Sustainable Percentage Increase above the current estimated levels of consumption of the eleven load centres under consideration.

The estimated annual sustainable percentage increase in fuelwood usage can be summarized by load centre as follows:

Cartwright	759%
Mud Lake	9589%

Black Tickle	94%
Postville	943%
Port Hope Simpson	1925%
Harbour Deep	179%
Roddickton	77%
St. Anthony	3%
Fogo Island	-76%
Little Bay Islands	163%
St. Brendans	154%

As is evident from the above information, only one load centre, i.e. Fogo Island, appears to be seriously overtaxing the resource base available. While St. Anthony is also approaching the limits of increased usage of the resource base, the other nine load centres have more than adequate fuelwood to satisfy present fuelwood consumption patterns.

BIOMASS UTILIZATION STUDY
RODDICKTON-MAIN BROOK REGION, NFLD.

EXECUTIVE SUMMARY

Results

This study examined the technical and economic feasibility of using forest biomass to reduce the amount of diesel consumed for electrical generation within the boundaries of the White Bay Central Development area. The major findings were:

1. It is technically feasible at this pre-feasibility level to replace some of the diesel capacity at Roddickton with a woodchip/wood waste fired boiler and steam turbine.

2. The base case payback period is just over 16 years, taking into account fuel savings and additional labour and maintenance costs.

   All payback calculations are based on full capital costs being borne by the project. No allowance or consideration has been given to either Federal or Provincial grants or economic assistance.

   The base case analysis does not assign any capital charges to the diesel only system for diesel replacement. The sensitivity analysis indicates that taking these charges into account could reduce the payback period by about 2 years.

3. At this level of study, a unit of about 1250 kW appears optimal. It would have an annual wood consumption of just over 17,000 t in the first year of operation for a total wood cost of the order of $536,000. The estimated capital cost of the system is approximately $2,000,000.

4. The diesel generation systems at Main Brook and Croque are not large enough to warrant replacement with wood-fired units at this time. The fuel savings are not high enough to offset the capital costs.

5. Other systems, such as gasification and peat-fired boilers, have potential for the future but presently are not economic.

6. Forest Resources: The quantity of chips required for the 1250 kW unit ranges from 17000 tonnes/year in the first year to about 23000 tonnes/year at the end of the study period. A forest biomass inventory indicates that there is sufficient wood fuel available to meet these boiler requirements.

7. Socio-Economic Impact: The installation of a wood-chip burning boiler is expected to have a positive socio-economic impact on Roddickton. A considerable proportion of the fuel costs will remain in the community (paid to the wood chip suppliers), rather than being sent outside to the oil companies. Jobs will be created directly, in the supply of wood chips. Additional jobs will probably be created indirectly in the sawlog industry. At present, sawlog operations are not economical because there is no market for the lower quality wood (formerly sold as pulpwood). A market for the low quality material as woodchips would encourage the re-establishment of the sawlog industry.

Implementation Plan

The project shows sufficient technical and economic potential to warrant further study. The following implementation plan is therefore recommended.

1. Make a final selection of equipment. This involves discussions and close involvement with Newfoundland and Labrador Hydro on such work items as:
    a) Evaluate fire tube and water tube boilers in meeting system stability requirements, and choose the appropriate type.
    b) Finalize unit type and size. Consider the option of a steam engine as an alternative to a steam turbine.
    c) Evaluate technical aspects of combined chips/diesel system operation.
2. Obtain firm prices for supply and installation of all equipment.
3. Establish a harvesting plan, in conjunction with provincial forestry officials.
4. Obtain firm prices for fuel supply.
5. Obtain firm estimates of maintenance and personnel requirements based on existing wood fired generation systems e.g. in the United States and Europe.

After a complete study of the above, a final decision on the project can then be made on sound economic and technical grounds.

The anticipated schedule for activities required before start up is shown in Figure S1.

Study Procedure

The procedure used in this study and the major conclusions at each point in the study are described below.

- Electrical loads in the areas were analyzed,
- Alternative unit sizes were considered.
- A preliminary economic analysis determined whether or not the system warranted further consideration.

At this point, due to cost factors, Main Brook and Croque were set aside, and the detailed analysis concentrated on Roddickton. (Main Brook may have some potential in the future if it is interconnected with St. Anthony.)

Quotes were obtained and capital costs were estimated for suitable units for Roddickton. A unit size of 1250 kW was selected, considering savings, additional labour and maintenance and capital costs of new equipment. Selecting the size was a major work item, since it involved consideration of how each unit would be used in meeting the loads at various stages of load growth.

Several other work items were undertaken concurrently. Conclusions are as follows.

Peat: Sufficient deposits are available but production costs are too high to make peat competitive with wood chips for firing boilers at present. If a wood chip burning boiler is installed, it would be designed to burn peat as well, so that if and when peat becomes available on an experimental basis or at a reasonable cost, it can be used.

Gasification: Gasification is a promising technology. At present, however, gasifiers are too expensive and unreliable for use in this area.

Waste heat use: The use of waste heat from the boiler/turbine combination and from the cooling units of the diesel generators was considered. There are two possible uses at present,

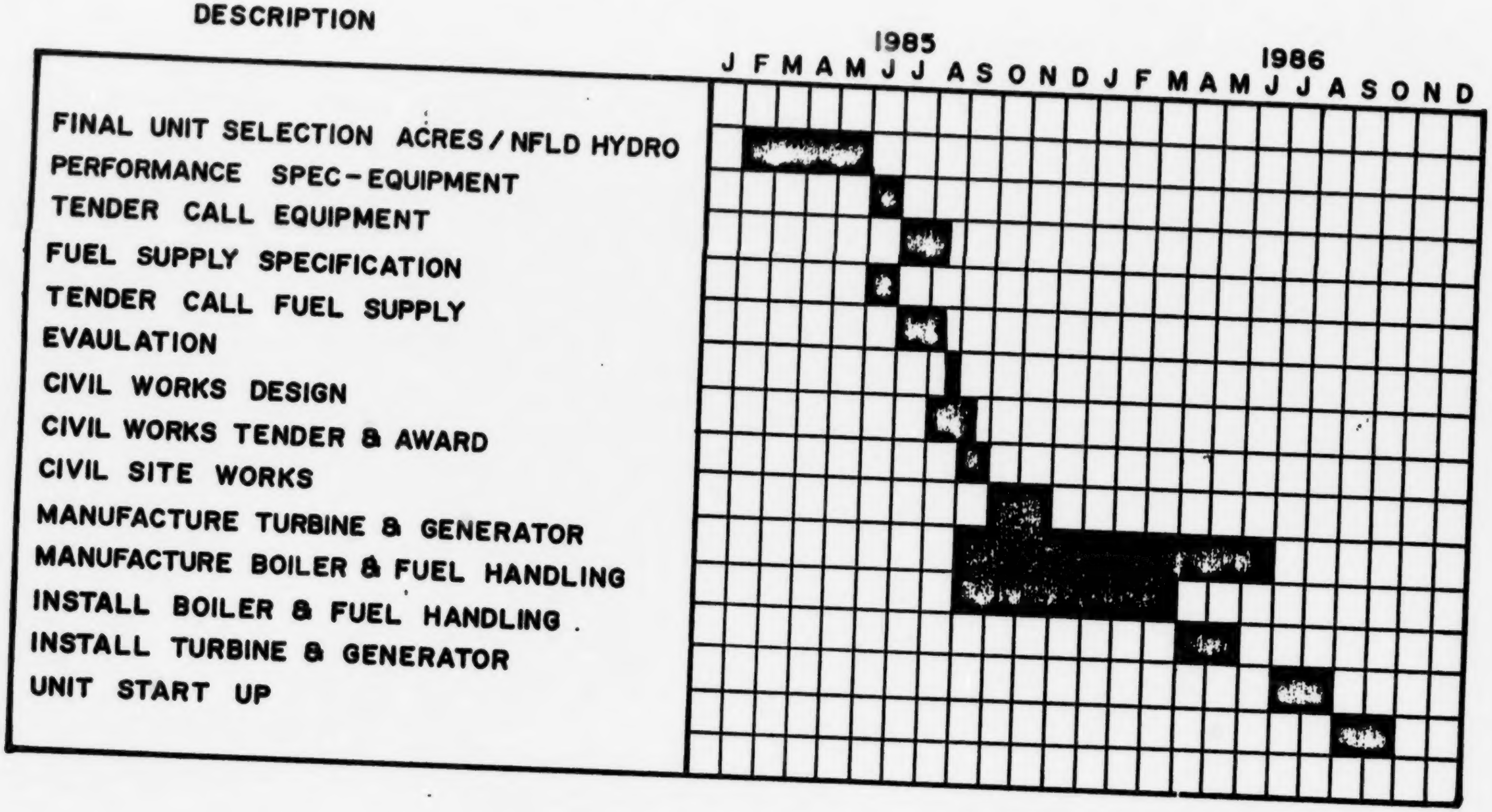
(1) to pre heat the wood chips to reduce the moisture content

(2) to provide district heating to two schools and a municipal building.

Due to potential layout and equipment problems in number (1) and the piping costs and reliability factor in number (2), no benefits were applied to the financial analysis from this source. However, in the event of implementation of the system, these factors should be reconsidered as they could have a positive impact on the system.

Forest inventory: A forest inventory was carried out, which showed that there are sufficient forest resources in the Roddickton Main Brook area to supply the long-term (20 years) requirements of a steam turbine generating plant.

Socio-economic analysis: A socio-economic analysis indicated that replacement of some of the diesel capacity at Roddickton with wood chips and sawmill residue will have a beneficial effect on the overall socio-economic situation of the region.



BIOMASS UTILIZATION STUDY
IMPLEMENTATION SCHEDULE

FIG.SI

FEASIBILITY OF FUEL PEAT PRODUCTION AND UTILIZATION AT HAY RIVER AND YELLOWKNIFE, N.W.T.

SUMMARY

Peat has been used as fuel for many years in other northern countries, but has not yet been used for this purpose in northern Canada, although large deposits are found here. The technology for fuel peat production and utilization is well developed in Europe, Scandinavia, and the Soviet Union, and horticultural peat has been harvested for many years in southern Canada, but it is not known whether this technology would be directly applicable to Canadian communities in the north. Factors such as permafrost, size of energy market, and climate make it necessary to evaluate the existing technology in terms of these local constraints.

A preliminary inspection of airphotos of peatlands near several northern communities revealed that the peat deposits near Hay River and Yellowknife show the most promise for potential development. The reasons for selection of these two communities are given, with an assessment of the suitability of the nearby peat resources for harvesting and utilization based partly on findings and observations during visits to the sites.

Secondly, the feasibility of fuel peat production at Hay River and Yellowknife is addressed. The technical and economic aspects of fuel peat production in relation to the estimated initial market for fuel peat are discussed.

The third part of the report examines the technical and economic aspects of fuel peat combustion with reference to Hay River and Yellowknife based on information from Finland where the technology of fuel peat combustion is well established.

The discussion of peat production and combustion systems is supported by the latest information gathered during a recent visit to Finland. During the visit, several peat harvesting operations and peat-fired heating plants were examined, and peat producers, peat machinery manufacturers, peat-fired boiler manufacturers, and fuel peat consumers were interviewed.

The report also contains the results of extensive calculations of cost and performance estimates of fuel peat production and combustion at Hay River and Yellowknife.

The study found that fuel peat production and utilization in Hay River and Yellowknife would be technically feasible, favoring Hay River, subject to confirmation

of quality and quantity of the peat resource and any unforeseen problems from local conditions like permafrost. If produced in quantity, fuel peat should be much cheaper than other fuels, and the cost of heat produced with peat should be only slightly more expensive than if produced from other fuels. As actual costs cannot be precisely predicted, they could only be determined through actual experience. The potential benefits of having a local secure supply of fuel, added local employment, and stimulation of the local economy arising from peat fuel production and utilization are additional attractions.

For these reasons, it is recommended that a demonstration peat production and utilization project be initiated at Hay River. There would be five main objectives:

- To confirm the quality and quantity of the fuel peat resource.
- To evaluate the performance of existing peat production technology under local conditions at Hay River.
- To determine actual cost of fuel peat production under local conditions.
- To determine the cost of heat production using fuel peat under local conditions.
- To expose technical advantages and difficulties of heat production using fuel peat under local conditions.

AN EXAMINATION OF ALTERNATIVE SOURCES OF ENERGY FOR DESCHAMBAULT LAKE, SASKATCHEWAN

ABSTRACT

This report describes the findings of a study of electrical energy consumption and alternative electrical energy sources for the community of Deschambault Lake, Saskatchewan.

The study finds that a growing number of residential consumers are required to expend a significantly higher portion of their income on electricity than residents of the rest of the province. Also, at the present rate of demand growth, the current deisel generating facility will shortly be inadequate to meet local demand.

Some preliminary recommendations are made on alternative methods by which the public utility company might resolve the "adequacy of supply" problems. The ultimate selection of the "best option" will require additional cost analysis, and definitive information on the near term practicality of connecting the village to the provincial grid network.

From the community perspective, the best option would appear to be the utilization of local peat or peat/wood resources for electrical power generation, in view of the significant socio-ecomonic benefits that would accrue from this alternative.

PEAT ENERGY FEASIBILITY STUDY

CAT LAKE, ONTARIO

EXECUTIVE SUMMARY

The Cat Lake Indian Community is located about 180 km north of Sioux Lookout, Ontario and depends on air transport for its supplies. It is not connected to the electricity grid and relies on diesel fuel for its main source of energy. Concern has been expressed about the high cost of diesel fuel and its vulnerability to interruptions in supply.

This study's objectives were:

- to assess the energy needs of the Cat Lake Indian Community;
- to evaluate the peat resource base; and
- to determine whether it is technically and economically feasible to meet the community energy needs by a peat energy conversion centre (PECC).

The study was undertaken for the Cat Lake Indian community with funding from the Remote Community Demonstration Program of Energy, Mines and Resources Canada; Indian and Northern Affairs Canada; and the Ontario Ministry of Energy.

The consultants conducting the study were Rak Engineering Ltd., Maunder and Britnell Engineering Limited and IEC Beak Consultants Ltd.

A profile of the community has been developed and examined in terms of population, education, employment and income. Projections for the community population, housing and required facilities have been carried out for the milestone years 1985, 1990 and 2000. These projections indicate that the Cat Lake population will nearly double by the end of this century with a corresponding increase in the housing units from 74 to 144. The total floor area of the community buildings will increase from 2346 m^2 (1985) to 3751 m^2 (1990) and 4861 m^2 (2000) respectively.

The projected energy needs for a 20 AMP house service scenario at the milestone years indicate an increase from 580,000 kWh consumed annually in 1985 to 1,150,000 kWh by the end of this century. The same projections for a 100 AMP service, which the community desires, would increase the annual consumption from 875,000 kWh in 1985 to about 1,730,000 kWh by the year 2000.

The total annual peat requirements for the recommended 100 AMP scenario and sod peat space heating is estimated to be 5,200 tonnes in 1985, 6,800 tonnes in 1990 and about 8,500 tonnes by the year 2000.

The evaluated peat resource base located within 10 km of the community is in the range of 1,500,000 to 2,000,000 tonnes of fuel grade peat; and it was concluded by the study that only a portion of these deposits would be utilized to meet the projected community energy needs. The estimated capital cost for the proposed peat harvesting facility is in the order of $950,000 with annual operating costs of about $100,000. The cost of peat delivered to a PECC varies from about $35/tonne at the start-up to $20/tonne by the year 2000.

The results of the technical studies indicated that there were several energy system alternatives to meet the community energy needs. The leading candidates were: a diesel generator system located in the community;

connection to Ontario Hydro grid; and a peat energy conversion centre. It was concluded that a peat-fired boiler and steam engine generator system, using proven technology, is entirely feasible.

Environmental and social impacts resulting from the interaction between the proposed activities of the Cat Lake peat development and the social environmental components have been assessed in generic terms. The study notes that some of the changes the proposed development will bring are considered beneficial, others unfavourable. A summary of social and environmental impacts together with possible mitigation measures and suggestions for research needed is presented.

The economic analysis of the recommended energy systems and various sub-system scenarios has been carried out. The options were financially evaluated on the basis of a single government body being responsible for providing, maintaining and operating each complete facility.

Consultant's Conclusion

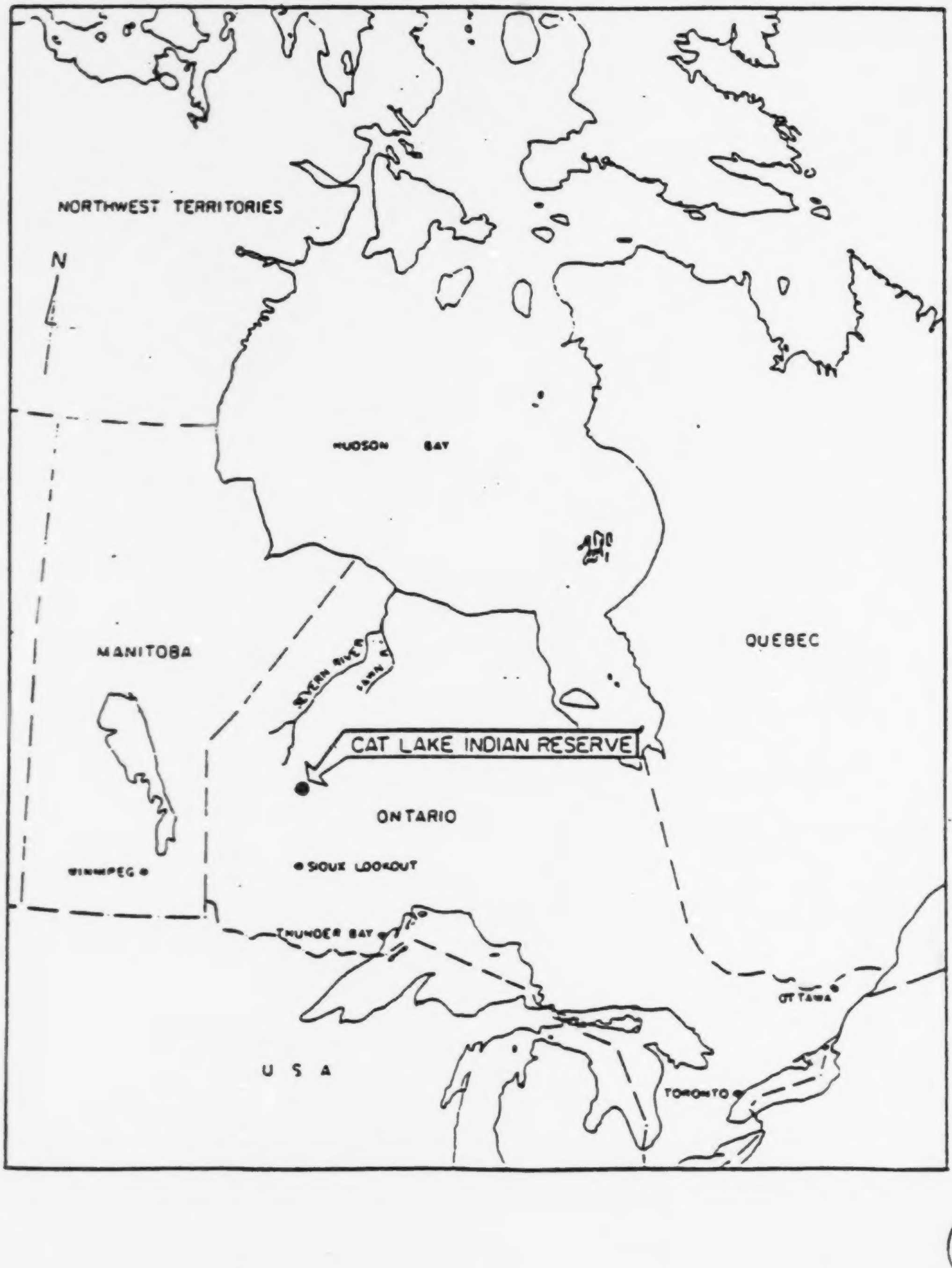
In overall economic terms, the recommended peat-fired steam engine option is superior for the 100 AMP scenario. If implemented, the estimated annual incomes flowing into the community would be $543,000 and $1,212,000 for the milestone years of 1990 and 2000 respectively. In addition to the estimated income benefits, the implementation of the proposed peat energy system also represents a very worthwhile training component for peat harvesting and peat energy conversion centre personnel.

Furthermore, the steam engine option represents a very efficient method of electrical generation for remote community applications. The average annual cost per kWh of $.42 in the year 2000 is about the same as today's average cost of $.40 per kWh in northern community diesel generator facilities. In terms of year 2000 dollars, the cost per kWh is 36% of the projected diesel generator costs.

It was concluded that the Cat Lake Community should utilize the local peat resource base and the available technology to substantially improve the quality of life on the reserve. It is evident that the proposed peat energy system and associated know-how would be beneficial to other remote communities with indigenous peat fuel resources. In some cases, the long term cost savings and social benefits of successful use of such an energy system may spell the difference between proceeding and not proceeding with given electrification projects. More project starts, by themselves, would create much-needed economic benefit to remote communities.

Energy, Mines and Resources Canada's Conclusion

A review by Energy, Mines and Resources Canada has found that the report's central recommendation, the installation of a community-scale peat-fired cogeneration system in the community of Cat Lake, cannot be economically justified. This position is based on an economic and financial analysis of the various technology streams evaluated in the study for the Cat Lake community. (These were: local diesel generator, connection to Ontario Hydro grid, peat gasifier, and peat boiler.) The review revealed that each technology generates a negative net present value, assuming a base case of no central electrification, indicating that the technologies evaluated for Cat Lake are neither financially nor economically viable.


NORTHWEST TERRITORIES
N
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QUEBEC
CAT LAKE INDIAN RESERVE
ONTARIO
WINNIPEG
SIOUX LOOKOUT
THUNDER BAY
OTTAWA
U S A
TORONTO

CAT LAKE INDIAN RESERVE
KEY PLAN

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HEAT PUMP OPPORTUNITIES FOR MAYO, YUKON

EXECUTIVE SUMMARY

The Village of Mayo, Yukon, currently uses a warm water well (18°C) to temper the village cold water well (1°C) to supply the village with domestic water. The water distribution piping of this northern village (63.6° lat. north, 135.9° long. west), is located in areas of permafrost, and although buried, is also subject to extremely cold winter weather (in excess of -50°C). The distribution of tempered water (8°C) appears to maintain water flow. Observations of the warm water well during sustained pumping indicate that more warm water than is needed for the village water system may be available for other uses. Since the population of Mayo (454) appears reasonably stable, additional warm water demand for the domestic system is not likely.

The Village of Mayo retained the services of Reid Crowther and Partners Limited, through a cost sharing program with Energy Mines Resources under funding available through the Remote Community Demonstration Program, to review the possibilities of heating buildings with any extra warm water which may be available. A comprehensive investigation of the ultimate geothermal capacity of the aquifer was not part of the study.

The study addressed a number of issues:

- review of well data
- location of major buildings
- types of existing heating systems
- retrofit opportunities
- cost of systems
- value of oil displaced
- other opportunities

The study identified two viable building scenarios for district heating:

- heating of five public buildings located along 6th Avenue;
- heating of the Judy Clarke School; .

utilizing heat pumps to boost the heating value of the warm water to extractable levels.

The building group which provided the best payback horizon based on the value of oil displaced was the 6th Avenue group, all of which could utilize heating coils placed on the return air side of the oil furnace of each building. A minimum capital cost requirement for this grouping of $117,000 was developed, which disposed of the heat pump discharge water into the village sewer system rather than using a re-injection well. Implementation of this minimum cost system will prove the validity of the heating capability and allow "hands-on" experience for the building operators. This grouping has an indicated payback period of less than 6 years, based on 1984 oil prices.

The Yukon Government has recently completed energy audits for the 6th Avenue group, and had documented the potential impact of conservation methods which would have less than a 5 year simple payback.

ENERGY CONSERVATION OPTIONS
HOT SPRINGS COVE, B.C.

SUMMARY

This report records the results of a study made to determine the energy conservation options available to the Hesquiat community located at Hot Springs Cove north of Tofino, B.C. and adjacent to the Maquinna Provincial Park hot springs.

The Hesquiat Band Council who commissioned the study were interested in reducing their overall energy burden and in investigating possible geothermal resources and all other energy options available in the area.

The community consists of 24 dwellings, a medical treatment facility and community building housing the school, Band office and shop. A site visit showed that the community's current requirements for electrical energy are met by diesel electric generation using two 60 kW diesel electric generating sets, operating alternately and consuming $25,000 fuel/year. Space heating in the houses is by woodburning stoves and water heating and cooking by bottled gas. The village, first established in 1974, plans to expand slowly as Band members currently residing elsewhere return to live there.

The opportunity for energy savings by upgrading of the houses were examined and repairs to windows, improvements to insulation, air tightness, and wood stove installations were proposed at a cost of $3,000 per house.

Various alternative energy sources were identified for the community and included:

- Expanded diesel-electric generation.
- Development of geothermal resources.
- Generation of electrical energy from a micro hydro installation.
- Thermal generation by wood burning both for space heating and the generation of electrical energy via a steam driven prime mover.
- Electrical generation by wind energy.

The diesel-electric generation option was examined as a base case against which to evaluate other energy supply options. It has the advantage of being a known technology capable of being expanded or contracted in size in accordance to the community needs. Oil is, at present, brought in by ship in bulk.

The expectation of the geothermal energy option, based upon the presence of a natural hot spring close to the village, was extensively examined. Two new hot springs were identified close to the village and, based on evaluation of water and gas samples from these springs and a study of the geology of the area, there is reason to believe that a supply of hot geothermal fluid might be confirmed by drilling. It is likely that this fluid would be best suited to community heating applications rather than electrical generation and the costs of drilling wells to prove the resource would be approximately $300,000. A further $400,000 would then have to be spent to harness and distribute the resources if the drilling proved positive.

The provision of electrical energy from a micro hydro scheme was evaluated. Two potential sites were identified within economic transmission distance of the village. Based on regional hydrological records an evaluation of the power potential of the two sites was made. This showed that the one closest to the village could not supply sufficient energy to meet the long term needs of the community while the more remote site some 10 km away could do so. The capital cost of a 500 kW installation at this second site would be $2,333,000. In addition to supplying all the village energy requirements there exists the possibility of supplying power to an adjacent logging camp until the village's energy needs grow to require the full output of the hydro scheme. At present the logging camp is expending $70,000/yr on fuel for electrical generation.

The possibility of generation of electrical energy from a wood-fired steam driven generator was investigated. No economically available waste wood supply, such as sawmill waste, could be identified and the large wood supply required from natural forests together with the need to staff the operation and maintenance of the system made this option unattractive.

The current practice of space heating using wood stoves was found to be most practical and various recommendations to improve and facilitate the harvesting and distribution of firewood to the houses were made.

The harnessing of wind energy by wind driven electric generation was investigated. The primary load identified for such randomly produced energy was space heating using thermal storage heaters and costs for such a system were approximately $225,000 for the wind generator plus $4,500 per house for the space heating installation.

An economic analysis of the alternatives showed that, should the community decide to increase annual expenditures to make more electrical energy available to meet the energy needs of the village, then the alternative of increased diesel-electric installation and construction of a micro hydro scheme were the most attractive. Increase in annual costs over current expenditures would be approximately $70,000/yr for diesel (with firewood space heating) and $280,000/yr for hydro (with all space heating by electricity).

Generation by wind energy was not found economically attractive and the development costs and risk to prove up the geothermal resource were considered too great to be undertaken by the community alone.

The report sets forth the methods, advantages, disadvantages and costs of increasing the supply of electrical energy so that a decision can be made by the community as to how and when to proceed.

SUMMARY

QUEEN CHARLOTTE ISLANDS TIDAL POWER STUDY
JUSKATLA NARROWS, B.C.

The vertical axis hydraulic turbine (VAHT) is a relatively new concept for generating hydroelectric energy from fast flowing rivers or tidal currents. The concept has been under development by Nova Energy Ltd. of Dartmouth, Nova Scotia.

An overview study completed in 1983 by B.C. Hydro (Ref. 1) examined power supply options on the Queen Charlotte Islands (QCI) and identified Juskatla Narrows as a potential site for tidal power development. That study specifically recommended follow-up investigations of the feasibility of implementing a VAHT installation at Juskatla Narrows.

The current study was initiated in June 1983, to assess the technical and economic feasibility of a VAHT installation at Juskatla Narrows as a means to reduce diesel fuel consumption on the QCI. Because of the off-oil nature of the study, joint funding for the study was sought under the Remote Community Demonstration Program administered by Energy Mines and Resources, Canada. A joint funding agreement was completed in June 1983 which provided a total study budget of $45,000 shared on a 50/50 basis between B.C. Hydro and EMR Canada. Nova Energy Ltd. were the technical consultants for the study and they received $34,867.

The basic development concept examined in this study was a 1000 kW VAHT unit installed in the eastern portion of Juskatla Narrows. The unit was assumed to operate in the freestream mode, hence construction of a barrage in Juskatla Narrows or Canoe Passage would not be required. Transmission was assumed to be via 20 km of 3-phase, 25 kV line to link up with the existing circuit at Port Clements. An extension to the basic development would be to add two additional freestream units of similar design. Due to water blockage effects with three units in

Juskatla Narrows, the rated output of the units would be increased to 3600 kW (1200 kW per unit). Additional transmission facilities would likely be required if the second and third units were added.

The major fundings of the overview study of the proposed tidal installation are as follows:

1. A 1000 kW VAHT unit at Juskatla Narrows would have a capital cost of 8060 k$ (October 1983) excluding interest during construction. A three-unit VAHT installation would have a capital cost of 18 490 k$.

2. The average energy output of the proposed one and three-unit VAHT installations would be 3.46 and 12.5 GW·h/a, respectively which is equivalent to an annual capacity factor of 40 percent. The power output would fluctuate according to semi-diurnal tidal variations.

3. The proposed VAHT units would be physically large, having a rotor diameter of 9.75 m and a rotor blade length of 9.25 m.

4. Economic analysis indicates that VAHT generation would be substantially more costly than expected savings in diesel fuel. For example, annual diesel fuel savings for the 1000 kW VAHT were estimated to be 840 000 L which is equivalent to 283 k$ at 1983/84 diesel fuel prices (33.7 ¢/L). The corresponding annual costs for the VAHT unit were estimated to be 645 k$ at an interest rate of 4 percent/a net of inflation. Similar conclusions apply to the three-unit VAHT installation.

5. The proposed VAHT installation should not pose any significant control problems for the Masset diesel plant. The most significant effect of the VAHT units will be increased operation of the diesel units at lower capacity factors.

6. There are still significant uncertainties regarding the commercial feasibility of VAHT units. The principal issues which should be addressed in further technology development work are operational reliability, cost effectiveness and structural integrity.

7. No significant environmental impacts are anticipated and public reaction appears generally favourable. However, more detailed information on the effects of VAHT units on fish and marine mammals is required. In addition, careful attention to other environmental issues and discussions with the local public would be required if the project is to proceed.

Because of the technical uncertainties and indicated poor cost effectiveness of the proposed VAHT installation, it is recommended that B.C. Hydro not fund further major technology development studies of a potential VAHT development at Juskatla Narrows at this time. However, if a research agency (such as the Canadian Electrical Association or the National Research Council) agree to fund further studies, B.C. Hydro could consider offering some services in support of this work. These services could include obtaining site information (e.g. tidal current measurements, water samples, site surveying, etc.) or possibly providing in-house design expertise to review results of model and design studies.

Model studies could also examine potential impacts of VAHT units on fish and marine mammals, and B.C. Hydro could nominate staff to review and advise on such studies.

A STUDY TO DETERMINE OFF-OIL OPTIONS
FOR POND INLET, N.W.T.

EXECUTIVE SUMMARY

This project was executed by the Pond Inlet Hamlet Council, under an agreement with Energy, Mines and Resources Canada, and funded by the Remote Community Demonstration Program. The consultant was Peter J. Poole, Ph. D.

In seeking an evaluation of the feasibility of developing local coal reserves as a community energy source, the Council wishes not only to increase local energy independence but also to develop local employment and small business opportunities.

However, under the terms of the Remote Community Demonstration Program, it was felt that the coal feasibility study should be accompanied by an investigation of the extent to which local oil product consumption could be reduced through the implementation of conservation measures. Accordingly, the study report is presented in two parts; one dealing with energy conservation options, the other with the prospects for coal development.

Part I: Energy Conservation Options

Of the total volume of imported oil products, 70% is used for space heating (45%) and power generation (25%). The total volume of heating and generating oil, 2,000 litres, costs approximately $2,000.00.

Of the 1,300,000 litres of heating fuel, 49% is used for residential heating. The main school building uses 16% and is one of 15 non-residential, single building consumers which take a total of 570,000 (44%) of the community heating fuel consumption.

The community consumption of electricity is 1,800,000 KWH's, and is divided into 1,300,000 KWH's (72%) for household use and 500,000 KWH's (28%) for non-residential uses.

At current rates of 51¢/litre and 31¢/KWH, the total annual household utilities costs are estimated at $1,050,000, averaging at $4,600 for heating and $2,800 for electricity.

The potential for developing a district heating system using waste heat from the power station appear to be concentrated in one of two major clusters of buildings: 1) the six garages close to the station, and 2) the school, and several buildings between the school and the power station. The garage cluster consumes 10% of the community heating fuel and the school cluster consumes 18%. A system to heat both groups would reduce the community heating fuel by 28%.

The 111 houses administered by the Pond Inlet Housing Association are subject to a program of rehabilitation and retrofit which will terminate in 1989. Nine 'matchbox' types of housing stock have been designated as 'beyond repair', 50 will be rehabilitated, 42 will be retrofitted and 10 are regarded as 'conservationally acceptable'.

Rehabilitation involves both increasing energy efficiency and upgrading the amenities of the houses by installing flush toilets; running water, pump-out sewerage, and services for heavy-duty electric appliances. Retrofit involves only replacing leaking roofs with heated attics, an operation which is expected to improve heating efficiency by at most 15%.

The response to rehabilitation varied widely with the type of housing stock. With model 455 units, average heating fuel consumption declined from 4,900 litres to 1,500 litres per annum. With model 436/439 units, average annual consumption fell from 7,000 to 4,000 litres.

Rehabilitation appears to have an effect of equivalent significance upon the consumption of electricity: With model 436/439 units, electrical consumption doubled; with model 455 units, electrical consumption was halved.

The increase may be explained by the provision for major electrical appliances which is a component of the total rehabilitation package.

This is supported by the fact that the electrical consumption of rehabilitated 436/439 units is similar to that for the new Weber and Woolfenden houses, which come already equipped to accommodate major electrical appliances.

In this context, the decrease in electrical consumption in rehabilitated 455 units cannot be easily explained. However, the sample was small (10) and it is conceivable that these rehabilitations did not make provision for major appliances.

The prevailing view of government officials responsible for housing and energy programs is that rehabilitation does result in a significant increase in electrical consumption. What this study indicated is the extent of that increase in certain cases. This could have definite significance in relation to the objectives of the Remote Community Demonstration Program.

On a community basis, the volume of heating oil imported is about double that of generating fuel. In many of the advanced or rehabilitated houses, the diesel fuel equivalent of the electricity consumed is higher than the amount of heating oil used. This ratio is obscured by the average figures for domestic consumption of both oil products. These reflect the large proportion of older houses with high heating and low electricity costs. The trend, resulting from the introduction of advanced housing and the rehabilitation of older units, appears to be towards an increasing consumption of generating fuel which tends to neutralize the gains achieved through thermal performance upgrading.

For example, the average electrical consumption of a Woolfenden unit represents 5,000 litres of diesel fuel, while the average heating oil consumption is 3,500 litres (the average heating consumption for all houses is 4,500 litres). For the 42 Weber units in Pond Inlet, electrical consumption represents 5,000 litres/unit of diesel fuel, with heating oil consumption roughly equivalent of 5,000 litres (these houses are not slated for rehabilitation and will only derive minor increases in energy efficiency from retrofits - 15% estimated).

An attempt was made to estimate the effect that current conservation programs, rehabilitation and retrofit, will have upon the total community consumption of oil products. The results indicated that, when rehabilitation of all Housing Association units are finished, the community heating oil consumption will fall by 9%; if all other houses in the community receive similar attention, the eventual effect would be to reduce consumption by a further 2%. A similar estimate could not be made for electrical consumption because of the anomalous results obtained on the comparative response of 455 and 435/439 types of rehabilitation.

Projections of Pond Inlet housing needs for the period scheduled for the rehabilitation and retrofit programs vary between increases of 32% and 465 over present stock. Even the low increase would offset the reductions in community consumption of heating oil produced by the current energy conservation efforts.

Part II: Coal Development

Inspection of historical records of coal sample analysis and two analyses of casual samples taken during this study, indicate that, though the coal may be suitable in terms of combustibility, the variation in the content of certain elements, especially sulfur, is such that decisions over the most suitable coal conversion technology cannot be made until a more systematic inventory and quality assessment is completed.

It appears likely that economies of scale and power generation from coal will have a severely limiting effect upon the choice of suitable technology. The higher the demand for electricity, the more likely that an economical generation facility can be designed. This may argue in favour of using electricity for space heating.

A second overriding condition affecting coal development is the question of locating a generating station. The comparison of a mine site location versus a community location should be a major component in a future design study.

Several programs for an inventory of the reserves were produced during the study. Examination of the previous analyses of coal samples led to the need to know whether there are accessible deposits of limestone, to be used in the control of sulfur emissions. This objective must be considered in an inventory program.

The Salmon River deposits were examined. It appears that, if the extensions to the visible seams remain in the same relation to the surface, a simple open-pit operation would be sufficient to produce the coal.

Two routes between the community and the reserves were reconnoitered. There were few obstacles to the construction of an all weather road that could be used by 5 ton dump trucks.

Coal combustion technologies were examined under two main headings: 1) space heating, and 2) electricity generation. Space heating would be achieved either through a warm air or hot water circulation system in a district heating configuration. The generation of electricity would entail raising steam for turbines with the additional possibility of using hot gases to drive gas turbines.

Other methods of using coal as the energy base, liquifaction, gasification, or as a fuel when mixed with oil, were felt by the experts consulted to be too complex and expensive to contemplate for Pond Inlet at the present stages of technology development.

Most of the phases of coal combustion technology reviewed in this study are under constant improvement. Much of the research and development is directed to producing technology suitable for communities such as Pond Inlet, that is, small-scale automatic, and environmentally acceptable.

This applies to simple room-heaters as much as sophisticated power generating systems. The community would benefit by continuing to monitor developments in this field.

Since all domestic fuel costs are subsidized to some degree, and since even those paying the maximum still only pay a flat rate regardless of amount consumed, there is effectively no financial incentive for householders to switch from convenient oil-based systems to coal-fired systems requiring greater attention and carrying perhaps certain operational hazards. This situation is aggravated by the general recollection amongst older residents of coal-fired heaters that were considerably less efficient and more troublesome than those available today.

Amongst the larger consumers, government agencies and commercial organizations, these may be a greater incentive to cut fuel bills, through budgetary necessity. With 15 buildings accounting for about 40% of the community heating fuel bill, substantial reductions could be attained with a minimum of energy distribution installations.

Coal-fired heating systems for small office buildings, schools, and factories is one of the most promising areas of current research and development. Moreover, the researchers developing these systems have acknowledged that they must compete with other energy sources not only in cost but also in ease of operation. Automatic stoking, ignition, and de-ashing are now featured on commercially available systems.

Several examples of such state of the art systems are described in the text. Finally, details are provided of a complete house designed around a coal-based natural air circulation heating system.

The prospects for using emerging technology for power generation from coal are less immediate but may improve considerably within a few years. Experts consulted felt that two combustion systems hold most promise, and developments in both should be monitored, at least until the coal inventory is complete. These were: 1) conventional stoker systems, and 2) fluidized bed combustion.

Stoker technology is simple, proven, and reliable. Moreover, a certain amount of research and development is directed towards improving these well-tried methods still further. It was even suggested that the community look for an 'obsolete' stoker in a region where these have been replaced by large generating systems (in England, some stokers, once converted to oil-burning are now being re-converted to coal-firing). However, this technology is not capable of reducing sulfur emissions without the addition of complex and expensive scrubbing systems which not only require limestone but produce large quantities of sludge.

The principal advantage of fluidized bed combustion are: 1) low grade fuels can be burned efficiently, 2) inherent capacity to reduce sulfur emissions, 3) high heat production for raising steam, and 4) potential for driving gas as well as steam turbines to produce electricity. While a fluidized bed combustion facility might cost less than a stoker-scrubber combination, some form of crushing and cleaning technology might be needed to prepare the coal. Pressurized fluidized bed combustion may be especially suitable for generating electricity and a schematic of such a system is shown in the text.

While the precise environmental impacts of coal development cannot be evaluated until further specific commitments are made to mine development and combustion systems, some idea of likely impact is required before such commitments are made. As a starting point, a provisional environmental impact matrix was compiled. It identifies the kind, but not the degree, of likely impact produced by various approaches to coal development.

A similar approximation was developed for the socio-economic cost/benefit of coal development. Various approaches to coal development are annotated in terms of the kinds of jobs that might become available and whether it would be long or short term employment.

CONCLUSIONS

1. Reductions in the total residential heating fuel consumption as a results of current rehabilitation and retrofit programs are likely.

2. This reduction in community heating fuel consumption is likely to be offset by increasing total demand as projected housing units are added.

3. Rehabilitation of older housing stock improves thermal energy efficiency of these houses by a considerable margin and is reflected in reductions in heating fuel consumption of as much as 70%.

4. Rehabilitation programs include upgrading the amenities of the housing stock by introducing the capacity to use major electrical appliances. Thus, rehabilitation may precipitate higher electrical consumption. The diesel fuel equivalent of electricity exceeds the level of heating fuel consumption. A comparison of the generating and heating fuel consumption of the newer housing stock supports this conclusion.

5. If the ultimate objective is to reduce the level of oil product imports, then this trend towards an increased consumption of electricity should be given serious attention - despite the fact the community consumption of heating fuel is double that of diesel generating fuel.

6. A district heating system using waste heat from either diesel or coal generators should concentrate first amongst the ten major buildings which consume 28% of the community heating fuel. Any surplus could be directed towards a further five buildings, which consume 16%.

7. If the coal reserves are eventually found to be as close to the surface as they are at the Salmon River exposures, a relatively simple and inexpensive open-pit mining operation is feasible.

8. The terrain between Pond Inlet and the Salmon River does not contain any serious obstacles to constructing an all-weather road using the equipment already operated in the settlement. A delivery route by water would not be practical.

9. Given the history of coal-heating with old, inefficient and hazardous units, and given that fuel oil consumption is subsidized on a flat rate basis, there is little incentive for Pond Inlet to switch from oil to coal.

10 For the major institutional and commercial consumers, a switch would be more sustainable. Moreover recent advances in automated, safe, and environmentally acceptable heating units for large buildings promise the highest reduction in oil consumption for invested capital and effort.

11. For the generation of electricity from coal, current operational plants are too large for scaling down economically for Pond Inlet. However, current research and development may well produce suitable technology within a few years.

12. The choice for coal combustion technology will probably lie between fluidized bed combustion and a refined version of conventional stoker technology. The most critical factor in exercising this choice will be the results of an inventory of the coal reserves available to Pond Inlet.

RECOMMENDATIONS

1. That an inventory of the local coal reserves take place as soon as possible.

2. That an attempt be made to determine the cost effectiveness of a district heating system supplied by waste heat from the diesel generators.

3. That those major consumers not included in the district heating system be regarded as candidates for the demonstration of an advanced automated coal-heating system. A design study for this demonstration could commence immediately, though finalizing the plan should await the results of the coal deposit inventory.

4. That an attempt be made to determine the impacts upon domestic electricity consumption of both the rehabilitation programs and the introduction of advanced housing.

SMALL-SCALE METHANOL PRODUCTION AND ITS POTENTIAL APPLICATION IN N.W.T. COMMUNITIES

EXECUTIVE SUMMARY

The purpose of this study has been to investigate, on a preliminary basis, the technical and economic feasibility of producing methanol from local natural gas resources in NWT. The prospective feasibility of methanol use in NWT communities is based on the availability of indigenous gas reserves in the NWT and on the availability of adjacent, as well as remote, communities to fully utilize the methanol produced. The sale of methanol outside NWT would not be economically feasible. The market for methanol is related to its ability to substitute for existing fuels, particularly highly refined P-50 furnace oil for space heating and diesel fuel for electricity generation. The transportation, handling and utilization of the methanol has also been investigated.

This four-week study has not involved any field investigations. It is based on a review of published sources, in-house studies and documentation within Stone & Webster and personal contacts with other organizations and individuals involved with development of methanol as a fuel. A previous Stone & Webster Report "Economic and Technical Feasibility Study of Distributing Natural Gas and/or Liquid Fuels to NWT Communities," March 1984,[1] identified various local supplies of shut-in reserves particularly at Parsons Lake, Taglu, and Titalik in the Mackenzie Delta, and Cameron Hills and Zama, south of Great Slave Lake. The study considered current methane production technologies and their potential application in NWT; transportation and handling of methanol; methanol as a substitute fuel for power generation, space heating and transportation, the emphasis being on the first two of these; safety and environmental factors; and overall economic feasibility of introducing methanol.

The principal findings are:

1. Small-scale methanol production by existing standard technology is technically feasible in NWT. However, economic assessments conducted herein conclusively rule out application of downsized standard production technology because capital requirements would be excessively high and community conversion potential too inherently uncertain to justify large, risky capital expenditures.

2. Recently published claims for non-standard, mini-scale production of methanol in portable plants cannot be substantiated at this time. As of March 1985 no such plants have been built and no engineering designs upon which accurate capital cost estimates could be based are available. The available cost data is, therefore, conceptual and must be considered at this time extremely uncertain.

3. However, the technical feasibility of methanol systems offers, at least in theory, a practical alternative to continued reliance on refined petroleum products. If one accepts, for the moment, vendor claims of cost feasibility for the mini-scale plants, the economic analyses portray favourable economic conditions. The sales forecasts for methanol in the selected communities are realistically attainable given financial support for a pilot project or limited conversion program.

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[1] See page vi

4. However, it is recommended that no pilot or demonstration projects should be seriously considered until adequate cost research yields reasonably precise capital, and Operating and Maintenance cost estimates.

5. Consideration of methanol as partial or total substitution for existing fuels in heat and power generation has indicated no obvious technical constraints and the report discusses some appropriate demonstration programs.

6. The results of widespread trials of methanol as prime or supplementary blending fuel in motor gasolines, although promising, indicate that this form of substitution is not recommended for application in NWT at the present time.

7. Safety and health hazards and environmental factors resulting from methanol substitution have been investigated and again appear to present no serious constraints.

8. A detailed review of existing legislation applicable in NWT should be performed before the general introduction of methanol as a fuel is permitted.

The prime recommendation is that additional research be focussed on developing a technical and economic data base for mini-sized (30-50 t/day), self-contained methanol plants in order to solidify capital and O&M estimates. This offers the best approach, at present, to the preponderance of shut-in natural gas in NWT and the formulation of lower cost alternatives to community energy cost burdens in the long run.

[1] Prepared for the Government of the Northwest Territories. Funded jointly by the Government of the Northwest Territories and Energy, Mines and Resources Canada.

EXECUTIVE SUMMARY

WASTE OIL FIRED HEATING SYSTEM FOR MUNICIPAL WATER AT HAY RIVER, N.W.T.

The technical and economic feasibility of a waste oil fired heating system to heat municipal water at Hay River is assessed in this project. Municipal water is drawn from Great Slave Lake and pumped to the Town, located 3 miles south of the pumphouse. During the winter months, December through April, the water must be heated at the pumphouse to avoid freezing in the transmission line. Fuel oil costs for the present system are almost $100,000 per year. The installation of a waste oil fired heating system described in this report, would effect a significant reduction in the annual heating cost.

The waste oil fired heating system is comprised of several components; including equipment for waste oil collection, pretreatment, bulk fuel storage and a waste oil fired boiler. A review of literature indicated that serious technical and operational problems are associated with burning waste oil. These problems are attributed to solids and water contamination of the waste oil. Pretreatment for removal of solids and water was judged to be necessary for the system at Hay River to minimize the effects of this contamination. A fire tube boiler and rotary cup burner were selected as being the equipment most suited for waste oil combustion.

Emissions of hazardous contaminants and the potential environmental impact from burning waste oil are also assessed in this project. The occurrence of hazardous contaminants in waste oil collected at Hay River is expected to be low for several reasons:

o Almost 40% of the total volume of waste hydrocarbons identified at Hay River are fuels contaminated with water and other non-hazardous substances.

- Incidence of used automobile oil is very low, representing 5% of total volume of waste oil available. Lead is the major contaminant of concern and is associated only with leaded fuels and lubricating oils from vehicles using leaded fuels. All other used oils identified at Hay River originated in diesel (eg. non-leaded fuel) engines.

- Hay River is a major transportation centre, and most waste oil generated at Hay River will occur within this sector. Major industrial contamination of waste oil (i.e. chlorinated solvents) is less likely to occur at Hay River than in larger urban centres.

A survey was conducted to assess volumes and types of waste oil generated at Hay River. Samples of waste oil were obtained. Analyses of the samples showed good fuel properties (except water content) and low concentrations of hazardous contaminants.

Generally, emissions of lead, barium, and hydrogen chloride have a potentially significant impact on the environment (eg. air quality). However, in this instance, these emissions are not expected to be significant.

This report concludes that the environmental affects of the proposed waste oil burning system, using the waste oil found in Hay River, will be much less than the limits suggested by authorities for safe lifetime exposure.

The capital cost of the waste oil system has been estimated at $312,000-$327,100. This includes $50,000 for a program for monitoring hazardous contaminants in the feed fuel, emissions and residues. This program is assumed to be carried out under the guidance of Environment Canada (EPS).

The operating and maintenance costs of the waste oil system have been estimated as $23,000 per year. This cost is incremental to operating and maintenance costs of the existing facility. This cost would replace the current fuel costs for the existing facility estimated to be $96,250 per year, based on a fuel price of 35 cents/litre. Annual savings are therefore $73,250 per year and the simple payback period on the capital investment is 3.6 - 3.8 years.

The above assumes that waste oil is freely available to the Town. If payment must be made to producers for their waste oil, operating and maintenance costs would increase. The current value of used oil at Hay River is estimated to be 9.8 cents/litre. Assuming this price is paid for 100% of the waste oil fuel, operating and maintenance cost would increase $26,950, to total $49,950. Annual savings are reduced to $46,300 and the simple payback period is increased to 5.7 years.

The waste oil system is suitable for replication at other northern locations. Pine Point, Yellowknife and the Beaufort area are identified as potential sites. Sufficient volumes of waste oil are generated at these locations to support a waste oil fired heating system. Heat generated could be used to heat municipal water (as at Hay River), public buildings or community centres.

The proposed waste oil fired heating system is expected to be a significant improvement, environmentally, in waste oil disposal at Hay River, over the current practices of uncontrolled burning and road oiling.

ENERGY OPTIONS FOR CHIPEWYAN LAKE, ALBERTA

SECTION 1.0 EXECUTIVE SUMMARY

Alberta Power Limited proposed that natural gas could provide an alternate fuel for use in their Chipewyan Lake Power Plant. The Power Plant currently uses diesel oil as a fuel. The use of natural gas and other alternate fuel for the entire community would be worth consideration.

Natural gas is, throughout most of Alberta, the cheapest fuel for domestic and light industrial use. The major disadvantage of natural gas is the high capital cost to distribute the fuel to the customer.

As anticipated natural gas offered significant economic advantages over the wood, propane, and diesel fuel that are currently being used as fuel in Chipewyan Lake. The greatest advantage occurs when the majority of the community converts to natural gas. When the use of natural gas declines the cost to distribute the gas increases thus off-setting the cost advantage of the fuel.

Wind and solar energy have failed to attract any significant number of people in Alberta away from natural gas. For this reason, it is expected that these energy sources would not be viable in Chipewyan Lake. Extra insulation in the dwellings could offer some savings in fuel consumed; however, the cost of retrofitting insulation to the predominantly log structures could be rather expensive.

The community of Chipewyan Lake has accepted electric and telephone utilities and natural gas is used in other native communities in Alberta so it could be anticipated that a natural gas utility would receive good acceptance in this situation.

In conclusion, it is apparent that natural gas could offer a significant advantage as a replacement for the fuels currently in use in Chipewyan Lake. The next step that should be taken to provide natural gas to the community would be to obtain a formal declaration of interest from each of the potential customers. This would provide the means to determine the total system demand and thus the cost of distribution service to the community could be provided by a local gas cooperative or by an existing utility company. Either option will have to examine the economics in the context of their respective corporate structures.

SECTION 3

CONSERVATION OF ENERGY

WASTE HEAT UTILIZATION FEASIBILITY STUDY, OLD CROW, Y.T.

Executive Summary

In the community of Old Crow, in the Northern Yukon, the Loucheux people have lived for hundreds of years. Over the last century, the people have been introduced to countless new foods, materials, and technologies. Some of these have been responsible for cultural conflict, and some have been of enormous advantage.

The people of Old Crow are presently examining methods of incorporating some of the new technologies into ventures which compliment and assist the new lifestyles in the community as well as the traditional ways.

In the interest of maximizing the benefits of energy and resources available to the community, the Old Crow Band obtained funding for a study to assess waste heat potential for greenhousing in Old Crow.

This study has been conducted through Phase 1 funding from the Energy, Mines, and Resources Canada (EMR), Remote Community Demonstration Program (RCDP). This report documents the Stage 1 requirements of the study to assess the feasibility of utilizing waste heat from the diesel electric plant for a food production facility.

The results of the Stage 1 study conclude that it is feasible and appropriate to utilize waste heat from the generators in Old Crow for an integrated food production facility. Based upon a preliminary evaluation of the technical, economic, and social factors involved, such a project appears to offer several significant advantages to the community.

The implementation of an integrated food production facility offers training and employment opportunities for the community. Local employment and the purchase of local materials for facility construction, fertilizer and feed, could also increase the cash flow in the community. In addition, the facility could offer a unique opportunity to conduct community based information transfer programs, and valuable research into successful food-production techniques in the far North.

Training will be an essential part of project development to prepare selected trainees with operational and managerial skills required for the facility.

A significant component of the Stage 1 study contained in this report is the evaluation of economic factors which will determine the extent of project implementation. The economic feasibility of this project is outlined below.

The following table summarizes estimated capital costs and one year operating costs for a waste heat recovery and distribution system, and a food production facility in Old Crow.

These calculations represent preliminary approximations based on standard systems and northern designs. Circumstances specific to final design may significantly affect the costs of buildings, equipment, and installation in Old Crow. These data are provided only as the basis for further study.

ECONOMIC SUMMARY
WASTE HEAT RECOVERY, DISTRICT HEATING SYSTEM AND FOOD PRODUCTION FACILITY: OLD CROW, YUKON

	Waste Heat Recovery and Distribution	Greenhouse and Garden Operation	Poultry and Egg Operation	Ancillary Space
CAPITAL COSTS				
Building cost @ $90/sq ft		36,000	36,000	63,000
Area (sq ft)		400	400	700
Equipment cost	340,668	30,150	5,400	1,000
Total	340,668	66,150	41,400	64,000
Cost/square foot (avg $120)		165	104	91
REVENUE	67,860	40,111	14,000	
ANNUAL OPERATING EXPENSES	4,620	6,389	7,837	
ANNUAL LABOUR EXPENSES	5,600	21,500	6,163	
REVENUE - OPERATING COSTS	$57,640	$12,222	$0	$0

SIMPLE PAYBACK on TOTALPROJECT (yrs): 7

PROJECT SUMMARY

REVENUE	$121,971
CAPITAL	$512,218
OPERATION	$18,846
LABOUR	$33,263
TRAINING	$100,000

The results of this Stage 1 study strongly favor more detailed investigation into the development of a waste heat recovery system and a food-production facility in Old Crow. It is recommended that the project proceed with the tasks outlined in the proposal for the second stage of this study.

HEAT RECOVERY POTENTIAL FROM DIESEL ELECTRIC GENERATING PLANTS IN POND INLET AND GRISE FIORD, N.W.T.

EXECUTIVE SUMMARY

This preliminary technical-economic report concerns the energy recovery potential (for space heating) in two small communities of the Canadian High Arctic: Pond Inlet (population:705), and Grise Fiord (population:105).

The objective of the study was to quickly test the cost-effectiveness/feasibility of recovering heat from diesel electric generators currently on-site in both communities. More detailed studies could provide refined conclusions and recommendations.

The methodology consisted of doing multiple runs of computer programs written by the contractor. The programs calculate energy values of heat production,recovery and market. They also give the economic break-even point of diesel electric sets for a full and partial market in each community, (given a complex array of technical and financial/systems/market assumptions in Appendices A and B respectively).

The layout of Grise Fiord is linear whereas Pond Inlet is comparitively compact in shape. Pond Inlet has 1000 KW generator capacity, while Grise Fiord has 400 KW.

The report concludes that there is some potential for heat recovery at both community sites, but the partial Pond Inlet Market presents the best opportunity for a more complete study with an investment break-even period of 6 years.

The reasons for the more advantageous break-even period relate to the greater volume of heat energy market and denser configuration of the partial Pond Inlet market, which in turn lessen the initial capital cost and minimize operational line energy losses.

The study was conducted in August 1983 for the Remote Community Demonstration Program of Energy, Mines and Resources Canada.

EVALUATION OF HIGH TEMPERATURE WATER HEAT DISTRIBUTION SYSTEM AND WASTE HEAT RECOVERY AT INUVIK, N.W.T.

EXECUTIVE SUMMARY

Inuvik's high temperature water (HTW) heat distribution system was built in the late 1950's. It now serves 243 buildings, and a small number of other consumers. Heat lost from HTW pipes keeps water and sewage mains from freezing in about half of Inuvik's utilidor system. All heat is generated by large boilers, installed in NCPC's powerhouses.

The purposes of this study are to determine what changes, if any, are needed to make the HTW system safe and reliable, and what changes, if any, might enhance the HTW system's economics. In particular, the possibility of recovering and distributing heat now wasted from diesel electric generators was analysed.

The HTW system shows few signs of aging, but some maintenance work is required. Distribution pipes show no sign of corrosion. Expansion joints are the only components which have been prone to failure: some need to be replaced each year. The type of joint seems appropriately chosen, but many existing joints appear to have been sized for a shorter traverse range than is desirable. Some may not have been installed at optimal compression for the installation temperature.

Most consumers' connections are appropriately designed, but a few should be rebuilt in the interest of safety.

The HTW system passes below a number of buildings, in most cases without risk to the security of the system. However, a serious fire in Samuel Hearne Secondary School could cut services to a large number of consumers to the north, and could endanger a large section of the water distribution system. The risk could be eliminated by building a redundant loop around the school, available for use in an emergency.

NCPC's heat generation plant has sufficient capacity to satisfy current loads. There is ample reserve boiler capacity for peak loads, and about 90 percent standby against failure of the largest unit. Reserve capacity in the distribution system amounts to 10 to 20 percent of current peak load.

About 73 percent of the energy input into the HTW system as fuel actually reaches consumers in the community or in the powerhouse area. The other 27 percent is lost, 13.5 percent in boiler flue gases, 5.3 percent elsewhere in the powerhouse, and 8.2 percent from the utilidor system. Utilidor heat losses could be reduced to 7.2 percent by cost-effective re-insulation measures, and to 6.6 percent by cooling HTW system temperatures in warmer months. Howerver, the latter measure could substantially increase expansion joint maintenance costs.

Energy conservation retrofit measures, even if widely applied in HTW consumer buildings, would not be likely to reduce HTW heat demand levels by more than 10 percent.

The HTW system has some inherent economic advantages over independant building heating systems. These include highly efficient industrial boilers, and the use of heavy fuel, which is less costly than the lighter grade home heating fuels.

The system's principal disadvantages are the heat lost by the HTW distribution system and, if it is considered, the capital cost of the distribution mains. Cost analyses indicate that, if the latter factor is neglected, it is slightly less costly to purchase heat from the HTW system than it is to install boilers and generate the same heat independently.

Consumption of HTW heat is not metered. It is believed that the somewhat arbitrary nature of the HTW heat billing system has contributed to loss of customers. Metering is costly, but would increase customer satisfaction, and would encourage heat conservation among consumers.

There does not appear to be any opportunity to capture heat wasted from the HTW boilers.

On the other hand, heat could be recovered from diesel engine jackets and stacks. The amount recoverable is much larger than could be used in the powerhouses, to heat fuel, and to heat domestic water at the water plant.

Heat is recoverable at a temperature between 225°F and 240°F, if stack heat is added after recovery of jacket heat. In order to use the greater part of recoverable quantities of waste heat, it would be necessary to distribute heat to a number of buildings at temperatures in this range, which is significantly below the HTW system's supply temperature of 350°F. This would involve converting some utilidor and some building heat exchangers for operation at the lower temperature range. Other elements of building heating systems would not be changed.

The cost of heat recovery equipment, utilidor additions and modifications, changes to building heat exchangers and other alterations is estimated to be $4.8 million. The annual saving is estimated to be $623,000 per year. The simple payback period would be 7.5 years, and the payback at a discount rate of 8 percent per year would be 12.5 years.

The economics of recovery and distribution of the major part of the heat now wasted are, therefore, only marginal. It must be noted, too, that economic forecasts such as these are very sensitive to changes in the real and relative levels of fuel prices, and to change in the discount rate.

However, analysis also shows that it may be cost effective to capture about half of the engine cooling heat now wasted, for use within NCPC's yard area.

Other opportunities for enhancing system economics are minor, being confined to replacing pipe insulation which has been lost within vaults and in a small number of utilidor runs.

DIESEL-ELECTRIC RESIDUAL HEAT RECOVERY IN THE NORTHWEST TERRITORIES

EXECUTIVE SUMMARY

Introduction

Electrical energy at communities in the Northwest Territories is generated primarily by diesel generating plants operated by the Northern Canada Power Commission (NCPC). The process of converting diesel fuel energy to electrical energy is relatively inefficient as conversion efficiency is only about 30 percent using conventional engine-driven generators. Typically, the remainder of the energy is lost through the cooling system (30 percent), the exhaust gas (30 percent), and radiation and miscellaneous losses (10 percent).

Because of the inherent benefits of residual heat recovery, some generating plants in the Territories have been modified or converted to recover and use the residual heat for district heating purposes. This study was undertaken to:

- evaluate the effectiveness of two existing residual heat recovery systems, one in Cambridge Bay (using jacket water only), and the other in Lac La Martre (using jacket water plus exhaust gas);
- determine the economic feasibility of providing similar installations at other candidate sites.

Objectives

Specific objectives of this study are paraphrased as follows:

A. To assemble construction, operating, and performance data for two existing heat recovery installations.

B. To evaluate and interpret data assembled from existing facilities to assess the designs, methods of operation, equipment, and materials used with the intent of optimizing heat recovery processes.

C. To apply the findings from A. and B. above to establish the technical and economic viability of recovering residual heat from the NCPC diesel-electric generating plant in each of 39 candidate sites in the Northwest Territories.

Methodology

Detailed monitoring of heat recovery and distribution facilities at Lac La Martre and Cambridge Bay was carried out during January and February of 1985.

Temporary instrumentation was installed at Cambridge Bay and Lac La Martre to measure and record flows and temperatures of engine exhaust gases, engine coolant, and heated water being used to collect and distribute residual heat. In addition, electrical power generation, fuel consumption, outdoor temperature and other data pertinent to the NCPC stations and residual heat user facilities were collected.

The data collected at Lac La Martre and Cambridge Bay was assembled and computer analyzed to provide the information for the technical and economic evaluations required for heat recovery systems and residual heat utilization. The conclusions drawn from the data evaluation at Lac La Martre and Cambridge Bay were extrapolated to apply to 37 other sites in the Northwest Territories to determine the technical and economic feasibility of installing residual heat recovery and district heating systems in these communities.

The data evaluation also provided a basis for recommendations regarding optimization of operation of residual heat recovery facilities.

Summary of Findings and Conclusions

General

1. The amount of heat available for recovery from a typical diesel generator plant per kW of electrical load is 1.1 kW from the engine coolant jacket cooling water system and 0.65 kW from the exhaust gas system.

2. By proper choice of residual heat users, their locations and system controls, close to 100 percent of residual heat available can be recovered as hot water for space heating.

3. Recovery of residual heat from jacket cooling water is generally more practical and economically feasible than total residual heat recovery from jacket water and exhaust gas.

Specific to Cambridge Bay and Lac La Martre

4. The total heat utilized from jacket cooling water at Cambridge Bay amounted to 45 percent of the total available residual heat from this source for the test period.

5. The total heat utilized from jacket cooling water plus exhaust gas at Lac La Martre amounted to 55 percent of the total available residual heat from these sources for the test period.

6. The jacket cooling water temperature returning from the heat recovery equipment to the engines is running in the 65 to 75°C range. This is below the engine manufacturer's recommended temperature and may lead to higher maintenance and premature failure of the units.

7. The exhaust gas temperature leaving the heat recovery (silencer) equipment is frequently below the dew point. Under these conditions, condensation and subsequent corrosion of the steel equipment and piping will occur.

8. The domestic hot water heating system temperature should be increased to at least 80°C for optimum utilization of available heat by the connected users.

9. Although the diesel generating units at Cambridge Bay are operated efficiently, those at Lac La Martre frequently operate at less than 50 percent load with resultant low thermal efficiency.

10. There are no scheduled maintenance programs for the residual heat recovery systems either at Lac La Martre or Cambridge Bay. NCPC staff are responsible to maintain the generators and engines but not the recovery equipment.

11. Valving and controls for the residual heat recovery equipment are mostly manual, and automatic features that do exist are not wholly effective. This results in erratic operation and control, less than optimum utilization of residual heat, and reversal of heat flow from user to the generator.

Other Sites

12. Depending upon location, design of facilities, electrical load and heat user demand, simple pay back of heat recovery equipment for NCPC stations in the Northwest Territories will vary from about three to well over 20 years (assuming efficient utilization of all the available heat), as detailed in the following tablulation.

	Simple Pay Back Period (Years) at 100% Heat Utilization		Annual Fuel Savings (1985)	
Site	Jacket Water Heat Recovery Only	Jacket Water and Exhaust Gas Heat Recovery	Jacket Water Heat Recovery Only	Jacket Water and Exhaust Gas Heat Recovery
Rankin Inlet	2.95	5.00	$161,218	$268,811
Igloolik	3.13	7.77	72,535	118,694
Spence Bay	5.09	7.06	74,255	121,508
Pelly Bay	4.40	7.66	39,197	64,140
Pangnirtung	5.37	13.83	59,742	97,760
Paulatuk	5.64	11.39	15,624	25,568
Fort McPherson	6.01	9.92	45,556	74,546
Lake Harbour	7.14	13.45	26,346	43,112
Aklavik	7.19	10.39	54,839	89,736
Sachs Harbour	7.77	10.94	37,970	62,132
Cape Dorset	8.12	7.07*	68,571	112,208
Broughton Island	8.27	18.86	30,663	50,176
Eskimo Point	8.45	15.39	63,976	104,688
Coral Harbour	9.18	8.08*	73,232	119,834
Fort Franklin	9.34	13.31	34,175	55,923
Arctic Bay	9.47	17.42	40,265	65,888
Coppermine	10.00	11.95	81,930	134,067
Rae Lakes	10.72	12.58	9,061	14,827
Pond Inlet	10.89	11.91	86,168	141,002
Gjoa Haven	11.20	10.82*	63,267	103,528
Fort Simpson	11.23	12.82	83,780	137,095
Hall Beach	13.83	12.68*	34,206	55,973
Whale Cove	14.11	17.32	20,194	33,044
Baker Lake	14.27	11.80*	118,680	194,204
Fort Liard	15.23	20.74	12,729	20,829
Repulse Bay	15.28	20.94	26,159	42,805
Fort Norman	15.34	18.42	21,900	35,836
Wrigley	16.04	67.71	7,252	11,867
Fort Good Hope	16.77	26.67	24,001	39,279
Grise Fiord	21.72	30.78	16,918	27,685
Holman	22.5	10.39*	34,580	56,585
Arctic Red River	22.20	35,83	8,408	13,758
Clyde River	32.15	28.03*	44,938	73,535
Snowdrift	38.85	33.53*	9,080	14,858
Chesterfield Inlet	74.58	36.70*	22,018	36,030
Nahanni Butte	78.40	99.59	2,747	4,496

*Sites which have a shorter pay back period with heat recovery from both Jacket Water and Exhaust Gas.

Recommendations

General

1. The Government of the Northwest Territories should establish a priority list for implementing heat recovery from NCPC stations at various communities in the Northwest Territories, based on assessment of the calculated payback period presented in this report.

2. The Government of the Northwest Territories should renew discussions with NCPC regarding maintenance and operation of both existing residual heat recovery facilities and those planned for future implementation. Clear understanding of responsibilities and remuneration regarding operations and maintenance must be established to ensure optimum performance and hence economic justification of capital expenditures.

3. In future designs of residual heat recovery facilities, selective use of automatic controls can optimize heat utilization and prevent adverse conditions for the diesel engines. Provisions should also be made to prevent reverse heat flow (from user to NCPC).

4. In future designs of engine exhaust gas residual heat recovery facilities, consideration should be given to constructing heat exchanger and all downstream exhaust piping and stack of stainless steel. This will allow more heat extraction from this source without the problem of potential corrosion occurring due to condensation in equipment and piping.

5. Design heat recovery systems based on 1.1 kW of jacket water heat and 0.65 kW of exhaust gas heat per kW of electrical load. Base total load on the average annual load factor as provided by NCPC.

Specific to Lac La Martre

6. Overhaul diesel generator units to improve thermal efficiency and whenever possible use Diesel Generator No. 3 only, since it is more closely rated to the load and thereby provides considerably higher thermal efficiency than Diesel Generator No. 1.

7. Upgrade existing heat exchanger by installing an additional 24 plates. Concurrently, raise the jacket water inlet temperature to about 85°C, if possible (to allow 80°C heating water temperature), and upgrade controls to maintain temperature within the specified range of 74 to 91°C.

8. Install controls on exhaust gas heat recovery system to maintain the exhaust temperature in the 150 to 175°C range to prevent condensation.

Specific to Cambridge Bay

9. Replace existing heat exchangers with a unit designed to provide a domestic hot water supply temperature within 5°C of jacket water temperature. Attempts should also be made to maintain the jacket water inlet temperature at about 80°C.

10. Replace manual switchover control valves on the domestic hot water system at the GNWT Buildings with three-way motorized diverter valves.

11. Replace the three-way mixing valve at the water treatment plant with three-way motorized diverting valve.

ENERGY ALTERNATIVES FOR ATLIN, B.C.

Executive Summary

This northwestern British Columbia community, approximately 30 miles south of the Yukon border, has experienced a gradual growth in tourism, a rejuvenation of placer mining and an increasing interest in pioneer lifestyles. Its population is about 340 yearround, swelling by about a third in the summer.

The community commissioned this study to: identify how energy is being used; identify alternatives to oil; explore waste heat recovery opportunities; and review available B.C. Hydro studies on possible Pine Creek small hydro development.

The approximately 70% of Altin residents heating solely or in part with wood used 2500 m^3 in 1983. With an approximately equal amount being harvested for timber and other purposes, the life expectancy of the nearby forest resource is 545 years. Home heating oil is the second most popular source for space and water heating. The community's diesel-generated electricity is used for lighting, appliances and power tools, but seldom for space heating.

The study concluded that, at a 100% load on the community's diesel generators, heat recovery could save about $110,000 worth of fuel oil a year. The heat recovery system and distribution costs are estimated at approximately $400,000. Consumers could expect to pay between $14 and $100 per million BTU, depending on their distance from the system.

The other energy source that appears to be viable is small scale hydro. A conceptual design and cost estimate are provided for four potential sites on Pine Creek. The cost to the community of buying diesel-generated electricity from B.C. Hydro at a subsidized rate of 5.66 ¢/kWh is cheaper than the estimated cost from either of the two most promising small hydro sites (6.0 and 6.5 ¢/kWh). Nevertheless, with Atlin residents looking at a possibly higher cost to buy electricity in the future, the idea of increased self reliance from their own small hydro source is appealing.

A number of other alternatives to oil are not considered feasible. These include natural gas, coal, geothermal springs, solar heating, wind and peat.

The study was conducted for the Atlin Advisory Planning Commission by Reid Crowther and Partners Limited with a contribution from the Remote Community Demonstration Program of Energy, Mines and Resources Canada.

WASTE HEAT UTILIZATION
FOR WOLLASTON LAKE, SASKATCHEWAN

1.0 EXECUTIVE SUMMARY

The Saskatchewan Power Corporation (SPC) commissioned Associated Engineering (Sask.) Ltd. [AESL] to undertake a study to investigate the economic viability of recovering heat from two new 600 kVA diesel generator sets to be installed in a new power station located at Wollaston.

The waste heat was considered as a source of heat for the new health clinic which is presently under construction, the proposed new school, a laundromat, the east side community water system, and some residences.

The technical results of this investigation may be applied to other communities subject to transformations to account for differences in climate, soil conditions, fuel costs, construction costs and the community layout.

Social and environmental issues were to be a part of this report. However, in discussions with the community, it became apparent that the proposed district heating system did not raise any immediate social and environmental concerns. Consequently, there is no special section in this report on these issues.

The investigation indicates that there is adequate heat available from the generator diesel engines to serve all the users identified with their mean winter heat requirements and a portion of their peak heating needs. The portion of peak heating needs served will depend on coincidence of demand.

Flue gas or exhaust gas heat recovery is relatively expensive. Since most of the heating requirements can be met with water jacket heat, flue gas heat should be considered only as an add-on where it is economically justifiable.

The viability of a district heating system is impacted greatly by the high cost of the underground piping systems. Consequently, the most viable systems will be those where the major user is located close the generating facility.

The initial economic distance for serving the new school at Wollaston is approximately 600 to 800 metres depending on the length of the heating season. This is based on a 15 year capital recovery. The economics only improve marginally for a 30 year life.

The proposed school and generating station at Wollaston are 1000 metres apart based on pipe run. If fuel oil costs are escalated at inflation, the project becomes marginal with time.

Fuel oil costs are a highly sensitive variable. If fuel costs increase at a a rate less than inflation, the project at Wollaston is not economical. If fuel costs increase at a rate greater than inflation then it can become economical.

The economics are also sensitive to demand and inflation. Inflation tends to make any of the systems more economical with time. The higher the inflation rate, the more economical the project becomes. In addition, if customers are selected whose demand will increase with time, these two factors are cumulative in favour of the project.

Service costs for residential users do not immediately cover the cost of their service pipe and heat exchanger equipment. With an average inflation rate of 7.8%, it will take over 10 years to offset the cost of a residential service in Wollaston.

Unless the school and generating station can be located relatively close to each other, a district heating system at Wollaston should not be undertaken until viability is proven elsewhere.

In examining the other sites, it is recommended that Deschambault be considered for a district heating system before any others in this study because: the generating station is located immediately across the street from the school; the proposed community water treatment plant is located within 200 metres of the generating station; other facilities such as teacherages and the community arena are located within 250 metres of the generating station; Deschambault is readily accessable by road, consequently, construction costs should be favourable; and fuel costs are not significantly less than at Wollaston. However, it is understood that there are plans to relocate the generating station in the near future. The implications of relocating the plant any significant distance from its current location should be discussed with the community before a new site is selected.

The priority for development of district heating systems from highest potential to least potential, based on relatively cursory examinations, is as follows:

a) Deschambault;
b) Stony Rapids;
c) Wollaston Lake; and
d) Southend.

Return on investment for Stony Rapids, Wollaston Lake and Southend will be long term at best and subject to economic vagaries such as inflation, fuel costs, heat demand growth and length of the heating season.

There is a good potential for saving 100 000 litres or more of fuel oil each year using district heating in Wollaston or several other communities.

District heating as outlined in this study can be economical for the utility, the consumer, and can result in considerable fuel oil savings, provided the consumers are located reasonably close to the source of the generated heat.

ALTERNATIVE GENERATION AND DIESEL HEAT RECOVERY IN REMOTE ONTARIO COMMUNITIES

SUMMARY

INTRODUCTION

Remote communities are those whose location and/or size have resulted in some degree of isolation. Many of the services and facilities taken for granted in more populated southern communities are limited or non-existent. The supply of electricity is one of those services.

Connection to a large power grid from which relatively inexpensive, reliably supplied electricity can be drawn is infeasible in remote communities. They commonly rely for electricity on small central diesel generating plants, or in many cases have no supply system at all. Where central systems do exist, the individual user's power allowance is often limited by either a low capacity service entrance or by the cost of electrical power itself.

In Ontario, there are over 41 communities; the minority having community electricity supply systems. Ontario Hydro operates and maintains this service in sixteen communities.

The cost of electricity production in remote Ontario Hydro supplied communities is very high relative to that produced for the power grid, particularly in air access only communities. In 1984, a production cost of $0.41/kWh is likely typical. In rail communities such as Armstrong the cost is somewhat lower. The cost of diesel fuel (0.63$/L-1983) which must be flown in and the cost of maintenance provided by regional personnel are major cost components.

Residents in Ontario Hydro supplied communities pay a subsidized rate ($0.0925/kWh-1984) for limited 20 amp service, equal to Ontario Hydro rural rates. The subsidy is provided from the Bulk System sales. Rates for commercial and institutional facilities are much higher. Government Services are charged the full production cost. Non-government businesses receive a one-third discount, subsidized by the rural retail customers.

In 1983, Ontario Hydro's Power Equipment Department undertook to investigate the feasibility of wood based, remote site generation systems, and diesel heat recovery and supply systems. Federal Government Remote Community Demonstration Program (RCDP) co-funding was sought and approved.

Initial investigations reviewed the general layout, potential diesel heat recovery applications and forest resource potential in four communities: Sandy Lake, Big Trout Lake, Pikangikum and Armstrong. Appendix A presents the results of these investigations.

COMMUNITY ASSESSMENTS

Wood Fuelled Electricity Generation

The study of wood based systems showed that more detailed study should be limited to the communities of Armstrong and Sandy Lake. Pikangikum initially appeared to have good local resources, but had been the site of significant forest fire activity several years earlier. The local inventory was decimated and the fire killed wood had rotted significantly. Big Trout Lake was found to have significant wood resources, but those areas which would have had to provide a large part of the wood supply for electricity generation were unavailable. The band identified those areas as for band members use only.

After some review with Energy Mines and Resources Canada personnel, it was decided to evaluate a wood fuelled electricity generating system in Sandy Lake. The Sandy Lake wood scheme was selected over that of Armstrong because of similar work likely to be done by others for that location. It was seen as more valuable at this time to consider a truly remote community.

Diesel Heat Recovery and Supply Applications

Big Trout Lake and Sandy Lake were selected as offering the best diesel heat recovery and supply opportunities. In Big Trout Lake, Bell Canada operates a large remote site staff residence only about 180 m from the Ontario Hydro diesel generator station. In Sandy Lake, the Ontario Ministry of Transportation and Communication has airport facilities, a bunkhouse and garage, only twenty metres from the Ontario Hydro diesel station. The Sandy Lake school, although 1200 metres away, was also examined.

Potential diesel heat recovery and supply applications in Pikangikum and Armstrong are either similar to those in Big Trout Lake or Sandy Lake. In Pikangikum, the best opportunity is the MTC airport facilities. The other major oil heated facility is the school which is even further from the diesel station than in Sandy Lake. In Armstrong, the diesel station is quite isolated. The closest facility is the CN bunkhouse and station house. These are quite large heat users, but the distance from the diesels, the route of the pipline under the tracks and in the case of the bunkhouse the complexity of a retrofit make such an installation infeasible. The community school and MNR office are even more distant.

In summary, as a result of the initial review, more detailed study was undertaken of three diesel heat supply situations and one wood based electricity generation option. These are summarized below in Table S1.

TABLE S1

Summary of Remote Site Energy Options Assessed

Option	Product	Remote Site	Customer	Energy Supply	Electricity Fuel Feedstock
1	Diesel Heat	Big Trout Lake	Bell Canada	Heat-21,000 to 36,600L oil equiv.	Diesel Oil
2	Diesel Heat	Sandy Lake	MTC Airport	Heat-15,000 to 20,500L oil equiv.	Diesel Oil
3	Diesel Heat	Sandy Lake	School-supply to one or two furnace rooms	Heat-33,000 to 82,500L oil equiv.	Diesel Oil
4	Electricity	Sandy Lake	Community	Electricity-850,000 to 1,250,000 kWh	Wood

From the Energy Supply column in Table S1, considerable variation in energy supply requirements is evident. This is due to uncertainty about the actual heating energy requirements, the percentage of the heat requirement which could be supplied by a diesel heat recovery system, and future electrical load growth. Several cases were examined for each option to determine the effects of various assumptions.

Diesel Heat Recovery and Supply Economic Feasibility

For the diesel heat recovery and supply applications, the economic results in Table S2 were determined.

TABLE S2

Economic Assessment
Diesel Heat Recovery and Supply

	Big Trout Lake Bell Canada	Sandy Lake MTC Airport	Sandy Lake School 1 Furnace Room Supply	Sandy Lake School 2 Furnace Room Supply
Capital Cost (1985$)	142,500	106,000	567,300	597,300
15 Year Life Cycle Present Worth (1985$) Operating and Maintenance Cost	65,300	42,400	145,200	237,400
15 Year Life Cycle Present Worth (1985$) Replacement Fuel Cost	-285,500 to -164,700	-159,400 to -119,500	-385,500 to -258,500	-642,600 to -431,200
Total 15 Year Life Cycle Present Worth (1985$) Project Cost	-77,700 to +43,100	-11,000 to +28,900	327,000 to 454,000	192,100 to 403,500
Present Worth Payback Period	Minimum 10 Years	Minimum 13 Years	--	--

A positive total indicates that the project costs more in present worth terms than remaining on oil. A negative total indicates the oil substitution project is feasible if a 15 year payback at rates of return (discount rates) used in this study are acceptable.

There are potential savings to be made in the Bell Canada Big Trout Lake case and the Sandy Lake MTC case. The Sandy Lake School case is infeasible. Figure 23 on page 52 in Section 3.4.2 of the body of the report shows the effect one way transport distance would have had on the school case results.

The Bell Canada case appears most feasible. The worst case where the project would lose money saves only 43 percent of the heating oil and is considered pessimistic. The major issues to be resolved before a project could be implemented are:

(a) The development of a policy on pricing and capital cost sharing for remote site diesel heat energy sales.

(b) Uncertainty over the likely electrical load pattern and diesel heat availability in Big Trout Lake upon connection of outlining mainland community areas to the system.

(c) Reduced diesel heat availability should an Ontario Hydro residence facility heated by diesel engine heat be installed.

(d) Acceptable payback criteria for public, institutional and private participants.

The Sandy Lake MTC airport facilities case is economically somewhat less favourable, but there are also some positive factors. Significant savings in the capital cost may be possible. Also, although the fuel requirement is uncertain, heat replacement is most likely almost 100 percent. Thus a net 15 year life cycle present worth project savings is expected. Before implementation is considered, the following issues would have to be resolved:

(a) The development of an acceptable heat pricing policy.

(b) The determination of the heating fuel quantities likely to be replaced in the future, taking into account energy management planning by the Ministry of Transportation and Communication.

Upon resolution, a re-evaluation could provide both Ontario Hydro's Regional staff and those of the MTC with the details necessary to decide whether to make a committment to the project. Less difficulty would be expected with payback requirements in this case since a longer payback would be more acceptable to a government agency than to private industry.

Wood Fuelled Electricity Generation - Economic Feasibility

For electricity generation from wood fuel, the alternatives illustrated in Figure S1 are examined.

FIGURE S1

Electricity Generation From Wood Alternatives

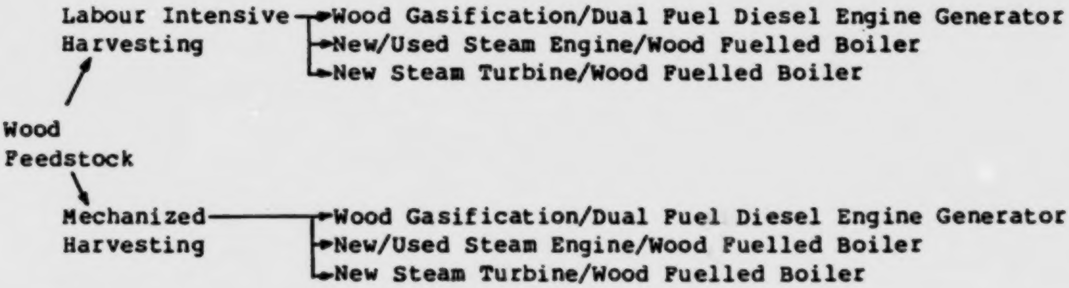
Labour Intensive Harvesting
Wood Gasification/Dual Fuel Diesel Engine Generator
New/Used Steam Engine/Wood Fuelled Boiler
New Steam Turbine/Wood Fuelled Boiler
Wood Feedstock
Mechanized Harvesting
Wood Gasification/Dual Fuel Diesel Engine Generator
New/Used Steam Engine/Wood Fuelled Boiler
New Steam Turbine/Wood Fuelled Boiler

Table S3 presents a summary of the economics from an operator's point of view of wood fuelled electricity generation, for the case of mechanized wood harvesting, with wood collected for electricity generation only. Costs would be higher for labour intensive harvesting, but slightly lower if wood for electricity generation and community heating were collected simultaneously.

TABLE S3

15 Year Life Cycle Present Worth Wood Fuelled Electricity Generation Costs

Cost Component	Wood Gasification	New Steam Engine/ Wood Boiler	Used Steam Engine/ Wood Boiler	New Steam Turbine/Wood Boiler
Capital Cost	$1,750,000	$1,895,000	$1,740,000	$1,825,000
15 Year Life Cycle Present Worth (1985$) Incremental Operating and Maintenance Cost	$1,023,000	$1,906,000	$1,906,000	$2,020,000
15 Year Life Cycle Present Worth (1985$) Incremental Fuel Cost	-$1,312,000	-$ 32,000	$ 638,000	$ 227,000
15 Year Total Life Cycle Present Worth (1985$) Project Cost	$1,461,000	$3,769,000	$4,284,000	$4,072,000

Based on these costs, wood based electricity generation is obviously infeasible in Sandy Lake and in other communities with similar circumstances from an operator's point of view. Sites having easy access and readily available low cost wood or wood waste may have different results. If the operation of the plant could be a part of a larger commercial operation, operating costs might also be reduced significantly.

Although the major issue to be resolved before implementation could be considered, economics is not the only issue. Others include:

(a) Band concerns over community wood availability, and woodlands harvesting's effects on trapping and hunting.

(b) Uncertainty over forest regrowth potential.

(c) Ontario Government Parks and Forestry policy.

(d) Regional Ontario Hydro operating personnel concern over the reliability, availability and maintenance costs of wood based equipment.

(e) Equitable distribution within the community of positive socio-economic benefits due to wood fuelled operation.

The following paragraphs briefly described these and the economic and technical factors affecting wood based generation.

Wood fuel costs are a major economic factor of wood based systems in Sandy Lake. In the labour intensive case, the relatively low productivity of harvesting and transporting result in costs of over $200/OD Mg ($190/cord). In the mechanized case, higher productivity is achieved, but at a significant cost in capital equipment which is under-utilized. Mechanized harvesting costs of over $90/ODMg ($80/cord) would be expected. In both cases, wood cost would vary somewhat inversely with the quantity required.

In conjunction with the high fuel cost, the low process efficiencies of the various wood conversion systems leads to very high fuel costs. Wood gasification/dual fuel diesel engine processes are claimed to have the highest full load efficiency, approximately 16 to 17 percent (wood on-site to electricity). This results in full load fuel costs of 12.7¢/kWh (mechanized harvesting) to 27.5¢/kWh (labour intensive harvesting) versus approximately 25.8¢/kWh for diesel fuelled generation in 1985. Operating experience to date would lead one to view the gasifier fuel costs as optimistic. Wood-fuelled steam cycle process efficiencies are much lower than the gasification process; 5.4 to 7.0 percent, not including 16 percent station service energy requirements. At these efficiencies full load fuelling costs are 25.4-33.0¢/kWh (mechanized harvestings) to 60.4-78.3¢/kWh (labour intensive harvesting). This is more than the 1985 diesel fuelling cost/kWh. Although wood fuel costs would escalate at a lower rate than diesel fuel, and may be cheaper in life cycle present worth terms, the saving will not likely be sufficient to offset additional operating and capital costs.

The capital costs of the wood based conversion systems in this report are typically $1,750,000 (1985$). This high capital cost relative to the unit size and to diesel units is a difficult issue to overcome, particularly in light of the limited fuel cost savings and the additional operating costs.

Additional operating labour requirements are a major economic factor. Diesel plants operating in remote communities require only intermittent operator attention. Wood based processes will require either full time operating personnel or greatly increased attention at the very least. The operating labour costs in Table S3 reflect the attention needed by these units.

Forest regrowth potential is a major concern and questionmark. Local community wood heating and wood fuelled electricity generation would require between 3600 and 5850 ODMg (3900 to 6450 cords) per year. This will require significant areas of wood (100 to 450 acres per year) to be cut each year based on existing stand volumes. To accommodate the long regrowth cycle in the north, harvesting will have to be undertaken further and further from the community.

In poor growth areas, soil conditions and growth rate could change significantly. In addition, the better growth areas may be unavailable as the community grows. Even in these better areas, the second rotation wood availability would be less than currently standing and the areas harvested would have to be larger.

In addition to the band's concern over the quantity of wood needed for electricity generation, a concern over the effects on Sandy Lake trap lines operators and those of neighbouring communities is evident. Assurances would have to be provided that no adverse affects would be involved or compensation provided. This may prove infeasible due to the uncertainties and costs invovled.

Regional Ontario Hydro operating personnel would not look favourably upon a system which would complicate their future plans. The trend is currently toward more automatic operation, less operator involvement. It is hoped that this will minimize the number of operator errors currently encountered and improve unit efficiency. A wood based system would reverse this trend and require highly trained operators, special equipment, and specially trained maintenance and support staff. A high probability of success and significant gains would have to be demonstrated before such complicated systems would likely be well received. No operational interference with existing equipment systems would likely be tolerated.

A further issue to be addressed is the Ontario Government plans for wilderness and waterway parks. There are currently proposals in the West Patricia Land Use Plan to conserve some of the land in the vicinity of Sandy Lake. These plans plus a potential requirement for environmental assessments for non-community wood harvesting would seriously influence the cost and ability to harvest available wood. Clarification of the implications would be required before even an apparently economical project could be committed to.

A wood fuelled electricity generation project would have significant positive social benefits. Direct full and part-time employment would be created in both wood harvesting and at the power plant.

(a) Harvesting - mechanized: 6 to 8 persons for 15 weeks per year
  - labour intensive: 13 to 15 persons for 38 weeks per year

(b) Power Plant Operation - 2 to 6 persons full time employment.

In addition there would be some indirect employment creation likely and the potential for a community wood harvesting system. The equitable distribution of economic benefits would become an issue to be examined and resolved.

Overall, the following recommendations are put forth for those preparing policy and making program decisions:

(a) Until the issues identified with wood use for electricity generation in remote communities are examined and resolved, wood as a fuel for electricity generation should not be considered by Ontario Hydro in remote communities such as Sandy Lake, not having large quantities of inexpensive wood fuel, easy access and low cost trained operators.

(b) Operators of diesel facilities should be encouraged to participate in diesel heat recovery and supply projects, taking into account heat medium transport distances, diesel heat availability and incremental operating expenses.

(c) Ontario Hydro's Marketing Branch should continue their development of a comprehensive policy on remote site diesel heat sales, allowing sufficient flexibility to accommodate site specific circumstances.

(d) Current and future remote site community facilities and community electrification planning should take into account the possibility of future diesel generator heat supply.

(e) Discussions should be held between Ontario Hydro's Regional Marketing and Operations representatives and those for Bell Canada's and MTC's northern operations regarding the possibility of diesel heat supply in Big Trout Lake (Bell Canada), Sandy Lake (MTC) and Pikangikum (MTC).

ALTERNATIVE ENERGY GENERATION SYSTEM FOR PINSENT'S ARM AND NORMAN BAY, LABRADOR

EXECUTIVE SUMMARY

A study was undertaken by Provincial Consultants Ltd. on behalf of the East Shore Labrador Development Association, to investigate the financial and technical feasibility of a remote village alternative energy electric generation system for the communities of Pinsent's Arm and Norman Bay, Labrador.

The project compared the life cycle costs which included initial capital, operating and maintenance costs of a new standard diesel electric generation system against five alternatives. The following are the six systems and their corresponding capital costs:

(1)	Standard diesel electric generation	431,000
(2)	Cycle charge*/diesel electric system	699,800
(3)	Photovoltaic/cycle charge/diesel electric system	914,000
(4)	Wind energy conversion/cycle charge/ diesel electric system	762,900
(5)	Photovoltaic battery system	3,993,700
(6)	Wind energy conversion battery system	1,098,900

The cycle charge system is by definition a diesel battery system. The diesel operates during periods of low battery charge, peak demand or the combination of these two conditions thereby reducing the running time of the diesel during low load conditions.

Neither community presently has a utility supplied central electric generation system.

The study concludes that all the alternative energy electric generation systems are not economically feasible at the present time because of the combination of high capital and low system efficiency. The cycle charge diesel electric system may be economical after the turn of the century if the capital costs can be brought down and the system efficiency improves.

It is recommended that a cycle charge diesel electric system be installed in a Newfoundland or Labrador community to verify the fuel savings projected for this system if the following criteria can be met.

(1) The community has an existing diesel electric A.C. distribution system between 10 to 150 kW in capacity, and
(2) The community will not be a candidate for grid inter-tie for the next twenty years.

Therefore, a reliable technical data base can be established to determine the fuel savings, the system reliability, manpower requirements, and battery maintenance for the proposed system.

The estimated capital cost to implement a 125 kW cycle charge demonstration project is $230,000.

*Cycle charge is a registered trademark of Mechron Ltd.

COMMUNITY ENERGY PLAN
BEAVER CREEK, YUKON

EXECUTIVE SUMMARY

PART 1

I INTRODUCTION

Acres International Limited and Arctech Community Energy Research Associates were retained to assist the community of Beaver Creek, Yukon in the application of a remote community energy planning program. While the study process concentrated on the problems and opportunities apparent in Beaver Creek, it is the intent that the energy planning process developed for that community can be adopted by other northern communities as well.

This energy plan for Beaver Creek is comprised of three principal areas of analysis. The initial endeavors in the community involved an identification of current energy consumption patterns through the analysis of historical fuel purchase records and individual surveys of the energy performance characteristics of all buildings in Beaver Creek. The next phase of the study, which was based on an analysis of the building performance data collected through the surveys, was an assessment of the means for conserving energy and reducing energy consumption through the application of various proven techniques for rendering buildings more energy efficient. Finally, the various means for utilizing alternative resources to supply the energy requirements of the community were investigated.

II ENERGY CONSUMPTION PROFILE

Over 862,000 litres of fuel oil with a value of about $396,500 are consumed annually in Beaver Creek. Of this, 47% is consumed to generate electricity in the community.

The other 53% is primarily utilized for space heating of buildings. To further disaggregate and understand the causes of energy consumption, the survey data for each building was utilized to calculate a retrofit potential index for the structure. This index is designed to indicate those buildings which have high energy requirements and are operating relatively inefficiently. These buildings are highlighted because they have the greatest potential for realizing savings in energy consumption through conservation.

In general, many of the buildings in Beaver Creek were found to be utilizing more energy than necessary to achieve desired comfort levels. Virtually all buildings in Beaver Creek could achieve significant reductions in space heat energy requirements through the sealing of air leaks in the building envelope and reduction of the thermal conductivity of the building through the retrofit of additional insulation. It is noted that air sealing is especially critical in a climate such as that experienced in Beaver Creek because the installation of additional insulation alone may merely exacerbate moisture damage problems in the buildings if effective vapour barriers are not first installed.

It was also determined that significant energy and cost savings could be achieved through very low cost means in the area of domestic hot water energy consumption. Most buildings in Beaver Creek could benefit almost immediately simply by lowering the temperature of the hot water heater, installing low flow shower heads, and insulating the water tank and the water pipes.

Improvements to oil furnace combustion efficiency ratings could also have significant impact on the amount of oil consumed in the community. Very few furnaces surveyed during the course of this study were operating near their efficiency capabilities. With good tuning practices, seasonal oil furnace efficiency should achieve about 75%. However, many of the oil heating systems in Beaver Creek showed an efficiency of less than 70%. General maintenance and tuning of the furnaces, application of more efficient combustion nozzles, installation of retention head burners and/or the use of automatic stack dampers are some of the measures available for increasing furnace efficiencies.

The conservation measures described in detail in this report would result in the saving of as much as 32% of the fuel oil presently used for space heating in Beaver Creek. In addition, the DHW conservation measures would serve to reduce some of the oil presently consumed for electrical generation, since most of the hot water heaters in the community are electric. Most of the conservation measures recommended are low cost provided local labour is utilized. Most of the conservation measures are simple enough that the building owner or operator could readily do the work required. For the bulk of these recommendations, the economic pay back period is exceedingly short and there is no doubt that these are fully justified.

III ENERGY SUPPLY ALTERNATIVES

A number of alternative resources and energy supply technologies were investigated for their applicability in Beaver Creek. These alternatives were assessed in terms of the technical feasibility, the extent and reliability of supply, the economic feasibility and the significance of the alternative to the community as a whole. The viable alternatives which could significantly reduce oil consumption in Beaver Creek were found to be the following:

Wood Fuel

Sufficient wood is available in the region surrounding Beaver Creek for it to become the primary fuel for space heating in the residential sector. Reasonably efficient wood-fired energy systems are available for such applications and the resulting delivered cost of useable energy is comparable to that for oil. If the community develops an efficient wood collection and distribution system, the benefits of using wood fuel become even more attractive. However, even if a community-wide initiative toward wood burning does not materialize, the alternative is sufficiently attractive such that individual building owners/operators should be encouraged to pursue wood-fired space heating.

Waste Oil Recovery

It is estimated that about 9,000 litres of useable waste oil is being discarded in Beaver Creek annually. The bulk of this comes from the Government of Yukon garage facility. Waste oil can be burned much like fuel oil in specially designed furnaces. The Government of Yukon garage itself is a large consumer of fuel oil and would be a logical candidate for the utilization of oil waste to reduce heating oil consumption. The annual savings on fuel oil purchases for the garage are estimated at

$4,000. Capital costs for the collection tank and furnace would be about $11,000. Thus, the pay back period is less than three years for this system.

Diesel Generator Waste Heat

On a larger scale, the installation of a diesel generator waste heat recovery system, and district hot water distribution system appears economically feasible. A suggested layout for the central plant system and distribution system is provided. Basically, it is recommended that virtually all of the larger buildings in the community with the exception of the customs building which is some distance away from the town, be connected to the distribution system.

The energy recoverable from the diesel generators and useable in the community is found to be in excess of the equivalent of 144,000 litres of fuel oil annually. Installation costs for the system are estimated at approximately $300,000 and pay back of these capital costs was found to be a period of about 5.5 years. Obviously, this system would result in substantial reductions in oil consumption in Beaver Creek.

Solar Energy

Increased utilization of passive solar energy is feasible and recommended in Beaver Creek. The opportunities for employing solar energy in existing buildings is probably limited due to the costs of renovations. However, all new buildings can achieve substantial energy savings if they are designed to maximize solar gains. The costs associated with such designs are relatively nominal for new buildings.

Other alternative energy supplies considered in the course of this study were not found to be viable in the Beaver Creek setting. The difficulties associated with these alternatives are documented in the report.

PART 2

The second part of the study involved developing a ten-step procedure which can be used as a guide to secure the energy future of any northern community. The steps are:

1. Establish an energy management/planning committee.
2. Quantify historic energy demand.
3. Determine efficiency rating for individual buildings.
4. Identify sources of energy waste.
5. Decide how to improve efficiency and reduce waste.
6. Identify, develop and utilize local resources.
7. Re-evaluate energy demand after conservation.
8. Assess available energy alternatives.
9. Analyze realistic energy alternatives.
10. Develop an ongoing energy accounting system.

The study was undertaken for the government of the Yukon with a contribution from the Remote Community Demonstration Program of Energy, Mines and Resources Canada.

BUILDING INVENTORY AND ENERGY USE SURVEY

SOUTH MACKENZIE VALLEY, N.W.T.

1984

EXECUTIVE SUMMARY

The 1984 Building Inventory and Energy Use Survey (BIEUS) is a follow-on from the 1982 and 1983 exercises. Collectively, the data and recommendations refer to the Mackenzie River communities up to the treeline.

The major recommendation of the 1984 study parallels that of the 1983 exercise:

- that a more aggressive use of the renewable wood energy around communities is feasible and desirable from both an energy dollar saving and a socio-economic development point of view.

The first steps that could give meaning to this major recommendation are as follows:

1) that for all rental/leased buildings, a gradually phased-in user-pay to-market pricing scheme should prevail to encourage each building user to find his/her lowest cost space heating fuel source.

2) that proper firewood harvesting (consisting of cutting and drying cycles) and land use management plans be created for each community south of the treeline.

The potential benefits of the steps above are:

- a considerable annual dollar savings in space heating costs ranging upward to estimated maximums of $7.8 to $17.4 million with full conversion from fuel oil to wood.

- an increased degree of community self-sufficiency based on a local resource and labour.

- opportunities for community employment and local business to provide fuel wood management and product-handling services.

This 1984 Survey Study was done under the Remote Community Demonstration Program of Energy, Mines and Resources Canada.

BUILDING INVENTORY AND ENERGY USE SURVEY 1983
LOWER MACKENZIE RIVER COMMUNITIES, N.W.T.

EXECUTIVE SUMMARY

This 1983 Building Inventory and Energy Use Survey (BIEUS) is a follow-on from the 19 exercise. Collectively, the gathered data covers the Mackenzie River Communities up to the treeline.

The major recommendation of the 1983 exercise is as follows:

- that a more aggressive use of the renewable wood energy around communities is feasible and desirable from both an energy dollar saving and a socio-economic development point of view.

The means that should allow this to happen are principally as follows:

- that for all rented and leased buildings a gradually phased-in user-pay-to-market-price scheme should prevail to encourage each building user to find his/her lowest cost energy source.
- that proper firewood harvesting (consisting of cutting and drying cycles) and land use management schemes be created for each community south of the treeline.

The potential beneficial effects are:

- considerable dollar savings in fuel oils (estimated to be in the range of $2.4 to $6.4 million).
- an increased degree of community self-sufficiency based on a local resource.
- opportunities for community employment and local businesses to provide fuel wood management and product-handling services.

The 1983 survey was done under the Remote Community Demonstration Programme of Energy, Mines and Resources, Canada.

OFF-OIL ENERGY GENERATION AND CONSERVATION OPPORTUNITIES FOR REMOTE COMMUNITIES

with particular reference to Hartley Bay, B.C.

1.0 EXECUTIVE SUMMARY

The objective of this study has been to identify potential opportunities for energy conservation and alternative energy sources in remote communities. Such opportunities will depend on their individual circumstances.

In parallel with this effort, a relatively simple computer program has been established for the study. This program consists of three modules. The first estimates energy consumption and cost for each sector and end use. The second produces demographic projections of population and changes in housing stock, from which energy consumption trends for the community over an extended period of time are obtained. The third carries out standard economic projections for any proposed option. Comparison with the diesel generator base case provides measures of economic benefit payback period, and off-oil saving.

The remote community of Hartley Bay, British Columbia, with a village population of 234, which is expected to grow at between 1 and 1.5 per cent per annum, was selected as a case study. Findings of specific interest are briefly summarized as follows:

- Hartley Bay spends approximately $190,000 per annum on all forms of oil, equivalent to $800 per person.
- This represents 90 per cent of the total energy input to the village.
- Residential space heating accounts for 60 per cent of the total.
- There is a wide disparity in house construction, making it necessary to classify housing stock into four types for energy assessment purposes.
- The poorest group of houses will be replaced in two years under the present replacement policy of Indian Affairs.
- The next best group (designated Type A) could benefit significantly from the installation of some form of floor insulation.
- Based on comparable data from non-remote communities, it is estimated that for the range of existing appliances at Hartley Bay, electrical consumption per household should be about 540 kWh per month. DIAND allows 700 kWh. Actual consumption per household averages 990 kWh per month. Overall electricity consumption in the village is about 78 per cent higher than it should be.

- A substantial part of this excess must be attributed to unauthorized electric space heating. In turn, this unauthorized use is directly encouraged by the policy of a flat-rate monthly electricity charge.
- Conversely, the consumption level of heating oil is substantially lower than expected.
- In fact, gross energy consumption in the village is about 80 per cent of that of a comparable non-remote community.
- Since a substantial portion of the oil consumption is inappropriately converted through the diesel electric heater system, at a much lower overall efficiency than direct oil space heating, the net useful energy consumption is even lower, at about 70 per cent. In other words, the community energy lifestyle is about 70 per cent of a comparable non-remote community. This is the extent to which the demand may be considered to be "capped". Under uncapped conditions, demand may be expected to grow as much as 40 per cent more than the present net useful energy level.
- The small scale hydro scheme of approximately 500-600 kW firm power proposed for Hartley Bay would virtually eliminate the growing consumption of approximately 440,000 L of oil per annum. The scheme would attract outlying population back to the village, possibly encourage local industry, and pay for itself in 14 years.
- Other short term off-oil opportunities with good payback periods are suggested. However, none represent a complete solution, and higher overall energy consumption levels can be expected, rather than reduced use of oil.

The report concludes with the recommendation that before considering other opportunities at Hartley Bay, a policy decision should be taken on whether or not to pursue the hydro option.

The report also recommends that a program of data collection should be instituted at other remote communities to determine consumption patterns and to identify similar off-oil opportunities.

COMMUNITY ENERGY PLANNING, STAGE 1

FORT CHIPEWYAN, ALBERTA

by Arctech Community Energy Research Associates

Energy Conservation Options

1. Rationale and Objectives

This report documents potential elements of an energy conservation program designed to reduce the dependence upon oil for space heating and electricity generation in Fort Chipewyan, Alberta. The work was accomplished through a site visit to Fort Chipewyan and meetings with community representatives and government agencies, to document environmentally, technically, and socially feasible approaches to such a program.

The following outline comprises the work statement for the first stage of a study for Fort Chipewyan as part of the Remote Community Demonstration Program of Energy, Mines and Resources Canada.

* Establish liaison with representatives of organizations associated with the supply, use and payment of energy used in Fort Chipewyan, eg. Alberta Power, DIAND, community leaders in Fort Chipewyan, Social Services (Canada, Alberta).

* Focus on ways in which the impact of constraints (home ownership and energy costs) may be lessened to enhance the success of energy conservation demonstrations.

* Itemize potential options for energy conservation in Fort Chipewyan, as well as factors which affect implementation of these options.

* Integrate the preceding energy conservation options into the existing community planning structure of Fort Chipewyan.

* Recommend the most feasible alternatives to be used to overcome these constraints, to ensure the success of an energy conservation program in Fort Chipewyan.

The study began in the first week of November 1983, with a community visit to Fort Chipewyan. Representatives of the EMR Conservation and Renewable Energy Office in St. Albert, and Arctech Community Energy Research Associates in Whitehorse, Yukon, spent four days in the community. During this time, the study team met with community representatives to assess their needs and interests relating to energy conservation. Fort Chipewyan, with an estimated population of 1,600, was chosen for this study because it is the largest remote community in Alberta. As well, the opportunities and problems associated with energy supply and energy conservation in Fort Chipewyan are typical of many other remote communities in Northern Canada.

2. Background

A. Economic

Fort Chipewyan is a troubled community. It is reported that the damming of the Peace River significantly altered the habitat of fur-bearing animals in the Delta; trapping is no longer a viable industry. The dam and the upstream industrial activity have also affected the fishing in Lake Athabasca. Caribou migration through the area ceased in the 50's; local opinion attributes this to intervention by government game management practices. Game is scarce and only a few families can hunt in the adjacent Wood Buffalo National Park. There are ongoing efforts by a few members of the community to establish a tourist-based industry to utilize the park environment. However, the lack of southern standard tourist accommodation has limited this effort.

B. Existing Community Services

The diesel-fueled generation facility in Fort Chipewyan supplies electricity to approximately 260 residential dwellings. Primary space heating is provided by wood to approximately 134 residences, by oil to approximately 105 residences, and by propane to approximately 21 residences. Water and sewer services to nearly all of the residences are presently nearing completion; however, most of the residences do not yet have the plumbing facilities to utilize this service.

C. Education

Local persons have been unable to meet educational requirements for entrance into apprenticeship programs at Fort MacMurray. Keyano College is located in Fort MacMurray with an extension service in Fort Chipewyan, which offers educational upgrading and life skills development. Formalized education is not held in high esteem; one teacher indicated that attendance at the local school generally runs at about 50%. Other individuals indicated that persons who attempt to upgrade themselves educationally are denigrated by their peers within the community. Some members of the community send their children to attend high school in Edmonton.

D. Construction Industry

While the functional elements of a localized construction industry do exist, it has been difficult to gain organized co-operation under a unified management. In discussions with an Indian Affairs representative in Edmonton, it was indicated that management problems with both Chipewyan and Cree Bands made it difficult for the Bands to build their own housing. Recent Band housing has been built by outside contractors who do not hire local persons with carpentry experience. A great deal of concern was expressed by administrators from both Bands, who felt that training in energy conserving construction techniques for Band members would help to alleviate this problem. Both bands want to build their own housing, and indicated that the type of training which Arctech has developed in the Yukon may well work in Fort Chipewyan.

E. Housing

i. Background

Most of the housing in Fort Chipewyan is in a deteriorated condition. This can be attributed to an inappropriate choice of building style, building materials, and construction techniques, which do not match the traditional lifestyles of the people nor the climate of the region. The native people traditionally practised a semi-nomadic lifestyle, relying heavily on the productivity of the Athabasca Delta. Small log cabins were built at traditional camp locations in the Delta. By the time the immediate wood supply was depleted, the bottom logs of the cabin had rotted from exposure to the moist soil, so the people moved a short distance away and built another cabin. A tradition of permanent housing is not ingrained in the culture. It is difficult or impossible to own land in the community. This factor, in combination with the government practice of providing housing, has made it difficult for the natives to assimilate the southern cultural values of land and house ownership, although a desire to own these does exist.

ii. Impact of Lifestyle

The control of moisture and condensation in the houses is a recurrent problem, since the traditional native cooking style relies heavily on boiling as the primary method of food preparation. This did not create problems in the log cabins, since even the tightest log structure can transmit moisture through the wood. However, when the people were relocated into mobile homes and plywood cabins, this traditional practice caused excessive moisture build-up behind impermeable exterior sheathing. This causes accelerated dry rot in the building structure, and rapid degradation of the buildings.

iii. Geographical Impact

The terrain of the area is a combination of bare rock, sand and muskeg with a high probability of discontinuous permafrost. In many cases, foundation instability has contributed to the structural degradation of the buildings.

iv. Impact of Building Practices

Common building practice does not provide for a continuous, well sealed, vapour barrier. If houses were constructed to current energy conserving standards, and vapour barrier integrity was attained, then condensation on windows would be severe, unless mechanical or natural ventilation was provided. However, the reliable operation of any mechanical system in remote community housing is a continuing problem. It will be easier and more ethical to develop simple building designs which can accommodate the lifestyle of the people, rather than trying to change cooking practices. The DIAND representative indicated that the department does not expect its housing to have more than a ten-year lifetime.

3. Data Collection

A. Objectives

A specific objective of this visit to Fort Chipewyan was to determine the extent of energy cost subsidies within the community to gain a better understanding of incentives and disincentives to energy conservation. To understand the factors contributing to the potential for energy conservation, questions were addressed to community members to determine who owns the houses and who pays for fuel and utilities. The data gathered during this visit should be considered an approximation.

B. Housing Administration

About 34 residences are privately owned. The Cree Band administers 113 residences, and the Chipewyan Band administers 38 residences. These houses are owned by the federal government, and held in trust and maintained by the Bands.

Alberta Housing and Public Works (AHPW) owns and maintains: 11 residences for provincial government staff; 10 residences for Metis; and 31 units for the Rural Mobile Home Program. An additional 4 AHPW units will be dismantled next year since they do not meet the requirements for water and sewer connections. Another 20 residences are owned and maintained by a variety of agencies including the Northlands School District, the Federal Government (RCMP, MOT, Parks, NHW, DIAND - Bishop Piche School), the Hudson's Bay Co., and Alberta Power.

C. Subsidies and Grant Programs

Residents of the 20 agency houses and the provincial government staff houses either pay no rent, fuel or utilities, or pay a fixed monthly rate. It is significant that these 31 households comprise 12% of the community residences, and that residents of these houses hold some of the most respected positions in the community. Their example may imply that energy subsidies are a "way of life" in the community.

Indian Affairs Social Assistance records indicate that during winter 82-83, 61 Cree and Chipewyan households were obtaining vouchers for fuel. From these data, it can be estimated that last winter, 35% of the households in the community received government energy subsidies which provided no financial incentive to conserve. More significantly, one third of the subsidized households were those of federal government professionals. Indian Affairs provides an additional 12 families with continuing grants which they budget for themselves. A fixed amount of social assistance is also provided in the community. With the exception of food vouchers, these people budget their own funds for energy and other expenses. Last winter 38 households received this form of provincial assistance. Households which receive continuing grants from Indian Affairs, and those households which receive social assistance from the provincial government, have the same incentive to conserve fuel oil and electricity as those households which do not receive financial assistance for energy payments.

Alberta Utilities and Telephones manages a rebate program which compensates applicants for the energy price difference between fuel oil and natural gas. This rebate program may act as a disincentive to energy conservation; however, if applicants were encouraged to use the rebate for thermally upgrading their houses, conservation would become a valid option to consider.

4. Community Interest

During this community visit, the concerns and priorities of residents were sought; emphasis was placed on those factors which relate to energy, as well as general attitudes in the community. Individuals contacted included homeowners, business persons, teachers, social workers, members of Town Council and Band Councils, the RCMP, engineering consultants, and community service organizations. The limited time available for visits necessitated that most of the effort was directed towards obtaining the opinions of community leaders and innovators. The nature of small communities also dictated that the "average" person in the community is unlikely to be expressing opinions to "outsiders". It wasn't until the fourth day of the visit that people on the street would acknowledge recognition and stop for a chat about the weather.

5. Energy Conservation/Alternate Energy Options

A number of project ideas were expressed in the meetings with community members. These included:

* specific training and skills upgrading for energy conserving construction so that people can build their own houses and apply energy conserving retrofits;

* waste heat recovery from the power plant for water system heating, or space heating in the new school, or community buildings;

* more efficient wood-fired heating systems and the use of chip wood; and

* a propane-fueled electricity generation and a propane vapour distribution system.

These ideas, and others which may arise in community meetings, should be discussed and priorized into a proposal from the community. At this time, it is feasible to respond to a strong community need for energy conservation information and to further assess the viability of more extensive programs within a context of a greater community awareness.

6. Recommendations

A. Information Transfer

Many people in the community expressed a desire for information presentations which would address the problems of discomfort in the houses caused by excessive air leakage and poor insulation. A few people have used styrofoam as an insulating sheathing in an attempt to increase the thermal integrity of the house. With the severity of the climate, it is likely that consideration will occur on the inside of the styrofoam, be trapped by the impermeable styrofoam and contribute to accelerated degradation due to dry rot. Similar circumstances may occur if additional insulation is placed in attics without first sealing moisture leaks from the rooms below. With information on the relative economics of fibreglass and styrofoam, as well as the necessity of a warm, continuous, air-vapour barrier, householders may be able to significantly improve the comfort and useful lifetime of buildings in Fort Chipewyan.

As well, information and materials application demonstrations of cost-effective and durable weatherstripping and air sealing techniques would be of benefit. It is also important for energy awareness to be introduced to the younger people in an entertaining format, since the undisciplined curiosity of children provides an opportunity to create an interest in conservation at a young age.

Some residents have attempted to reduce heat loss by stapling polyethylene on the outside of windows. This is not as effective as interior application, and in some cases can cause additional problems with trapped moisture. With the recent introduction of waste and sewer service, it is likely that many electric hot water heaters will be installed. This will significantly increase the demand for electricity and oil for power generation. At the user level, this increased demand will likely exceed 500 kWh per month per household. At present energy costs, the household will pay three times as much for electric hot water then propane fired hot water. Information such as this, combined with an understanding of electricity billing policy and basic information on water conservation, may also benefit the community.

It is recommended that a series of evening seminars and Saturday or weekday workshop demonstrations of simple low-cost/no-cost energy conservation techniques be presented in the community this winter. In addition to providing a forum for information transfer, this may also initiate an awareness of energy use in the community, and provide a focus for the generation of a community based proposal to RCDP for additional training or demonstration projects. If Arctech provides the curriculum and delivery for these seminars and workshops, then the opportunity would exist to assist the community in the development of a proposal.

B. Community Energy Profile

It is further suggested that a more detailed community energy profile be developed for Fort Chipewyan. Such a profile would aggregate and assess the validity of earlier reports relating to housing in the community as well as establishing building specific energy consumption and energy use efficiencies for each building. All buildings for which fuel and electricity records are available would be assessed on a kilojoules per cubic meter per degree day basis, and a retrofit potential would be determined. Anomalous buildings would be given a detailed survey with the co-operation of the occupants.

It is suggested that a minimum of two weeks this winter be devoted to the implementation of an energy awareness program, specifically tailored to the requirements of the people in Fort Chipewyan. This program would consist of information transfer and liaison with the community for the preparation of proposals from the community to EMR.

AN ENERGY OVERVIEW FOR FOND DU LAC, SASKATCHEWAN

EXECUTIVE SUMMARY

Introduction:

From May to October, 1984 Eneraction Resources, Inc., conducted a study of the energy use, needs and alternatives of the housing located in Fond-Du-Lac, Saskatchewan.

Meetings were held with community leaders and construction crews to discuss the findings of this study and advise the crews on energy conservation techniques. An analysis was also completed on the costs of retrofitting the 'average' home and various funding programs were identified.

A Community Handbook was also prepared which is a reference guide for use by the community on energy conservation and wood heating in their homes.

Findings:

1. Houses have not been built to the Arctic Housing energy standards required for the Fond-Du-Lac area.

2. All houses do not have enough insulation in the walls, attics or floors.

3. Homes need better weatherstripping around doors and windows.

4. Construction crews need to be trained on how to properly install air vapour barriers, otherwise, the new housing will fall apart because of moisture getting into the walls and attic.

5. Chimneys in many homes have never been cleaned.

Recommendations:

1. New homes should be built to Arctic Housing Energy Standards.

2. Existing housing should have a higher level of insulation installed and they should be made more airtight.

3. A training program for local construction crews on how to properly build an energy efficient home should be implemented.

4. Stoves and chimneys should be checked out more often – chimneys should be checked and cleaned at least twice a year. Also, in the future, all wood stoves which are purchased should be the airtight design or central wood furnaces.

Funding:

1. Funds are available from a number of government programs which can pay for most of the costs of installing extra insulation and weatherstripping in existing homes.

ENERGY CONSERVATION FOR NORTHERN SASKATCHEWAN SCHOOLS

Stony Rapids, Brabant Lake and Camsell Portage

EXECUTIVE SUMMARY

This study has been prepared for the Northern Lights School Division. The objectives of the study were to prepare an energy profile of three northern schools, a ranking of energy conservation options for each school, and a manual detailing an implementation plan and energy budget for each school. In this way the Northern Schools may take advantage of energy conserving options and reduce the substantial yearly energy bill.

Each school was energy audited during the week of December 10, 1984. The average outside temperature at the time of the audit was approximately -40°C. The audit procedures for each school included:

- A thorough review of the energy bills for the past three years.
- A study of the architectural, mechanical and electrical drawings.
- A familiarization of the maintenance and operations manuals.
- An interview with the school principal.
- An interview with the school maintenance personnel.
- An on-site survey and extensive inspection of the school.

The findings for **Brabant Lake School** were generally as follows:

- Well maintained.
- New and efficient energy systems.
- Electric heaters installed in vestibules and crawlspaces.
- Ventilating systems needed attention and are wasting energy.
- Night setback thermostats and delamping will save a significant amount of energy.

The findings for **Camsell Portage School** were as follows:

- No regular maintenance.
- Energy systems were in poor condition. One furnace is being replaced due to a cracked heat exchanger and the other furnace is an older inefficient model.
- Both furnaces should be replaced with high efficiency oil burning furnaces.
- Night setback thermostats should be installed.
- Lighting system should use low wattage long-life tubes.

The findings for **Stony Rapids School** were generally as follows:

- Moderately maintained.
- The energy systems range from old and inefficient to modern and highly efficient.
- The older furnaces should be upgraded to modern efficient furnaces.
- Automating the industrial arts room ventilation will save a substantial amount of energy.
- The gymnasium ventilation system is not correctly controlled and school staff are not aware of the proper operation of the controls.
- Night setback thermostats and delamping provide paybacks of six months or less.

Details of each schools' findings and recommendations are contained within the report. All the recommendations have a payback of five years or less and can be implemented by school staff or maintenance personnel.

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Some generic findings from the schools were:

- Ventilation systems needing more attention and checking to ensure proper functioning.
- Old inefficient oil furnaces should be replaced with new efficient furnaces or where feasible with high efficiency propane furnaces.
- All single pane windows in wood frames [which require annual caulking] should be replaced with double pane windows in thermally efficient frames.
- Water efficient shower heads should be installed to minimize hot water consumption on the average yield a pay-back of three (3) months.
- Night setback thermostats will significantly reduce energy consumption.
- Delamping and/or relamping with low wattage tubes will save electrical energy and on the average be paid back in two (2) years.
- Caretakers must be instructed to vacuum furnace filters once a month.

In most cases the above findings and recommendations can be applied to all the schools in the Northern Lights School District.

ENERGY CONSERVATION AND OFF-OIL STUDY
FOR INSTITUTIONAL BUILDINGS IN SASKATCHEWAN'S REMOTE COMMUNITIES

1.0 EXECUTIVE SUMMARY

1.1 Introduction

This Study entitled "Energy Conservation/Off Oil Study for Institutional Buildings in Saskatchewan Remote Communities" examines alternate energy sources and energy conservation measures for ninety-three buildings in ten northern Saskatchewan communities.

This Study is one of eight sponsored by Energy, Mines and Resources Canada under Phase 1 of the Remote Community Demonstration Program (RCDP).

The Report assesses the potential for alternate energy use in one part and the energy conservation measures that could, through retrofitting and operation, reduce oil consumption in the second part.

The alternate energy sources reviewed included the possible use of solar energy, wood, peat, wood gasification, wind generation and small scale hydro power generation. Consideration of small scale nuclear power was omitted because of lack of technical and cost information.

The second part deals with energy conservation measures, identifying viable retrofit options for the category of buildings investigated, and which options are applicable for the respective buildings based on a five year payback or less. It further identifies the retrofit costs, annual energy and energy cost savings for the recommended retrofit measures. This information is summarized and presented in the summary chapter.

1.2 Description of Communities' Locations and Buildings Investigated

The communities of the facilities studied are in the northern half of the province between the 50th and 60th parallel and include from west to east: Garson Lake, Camsell Portage, Fond du Lac, Stony Rapids, Black Lake, Wollaston Lake, Southend, Brabant Lake, Deschambault Lake and Kinoosao. Of the ten communities, only four are serviced with outside connecting roads. The other rely on barge, air transportation or winter roads for outer access.

Electrical power in all of these communities is locally generated with small portable type diesel generating plants.

All of the institutional buildings use fuel oil fired heating systems with the exception of three new ones which use propane gas. Most of the facilities use propane for cooking stoves, oil for water heating and electrical heat for clothes drying. Some buildings use electric water heaters. Only one facility (Brabant School) has dual wood/oil fired furnaces which have been fired with oil only.

The institutional buildings include schools, health clinics, small office (Resources and Band offices), R.C.M.P. detachment facilities, assembly halls, recreation facilities and small telecommunication trailers and portable type power plants.

The agencies responsible for the buildings include both Federal and Provincial Departments as follows:

Building	Federal	Provincial
Schools	D.I.A.N.D.	Northern Lights School Division
Health Clinics	Health and Welfare Canada	Saskatchewan Health
Band Halls and	Band & (DIAND)	
NH/NS offices and Halls		NH/NS, Sask. Urban Affairs
Saskatchewan Parks and Renewable Resources (PRR)		Saskatchewan Supply and Services
Power Plant		North Sask Electric Ltd.
Telephone Building		Sask Tel

The total 1984 energy consumption for the buildings investigated was 1,727,443 kW of power costing $585,925 and 261,064 gallons (1.19 ML) of heating fuel costing $464,759.

Construction of the buildings consisted mainly of wood frame and sided structures with gable truss roofs and crawl spaces either heated with perimeter insulation or non-heated with insulated floors. Approximately 50% of the buildings are assembled from prefabricated portable units. The buildings are generally insulated to RS12.1 walls and RS13.5 ceilings standards. Windows are generally double glazed vinyl slider type with sigificant air leakage.

Heating systems are predominantly (90%) oil fired hot air furnaces, 25KW size range and numerouly used in larger buildings. Hot air distribution is generally by metal duct system located in the floor or crawl space.

Very few of the heating systems (7) are equipped with mixed return/outside air ventilation systems. Some rely on fresh air by removing the furnace fan covers and permitting drawing in of outside air through the combustion air inlets.

Some of the buildings (two schools and two health clinics) are tentatively slated for replacement (Wollaston, Fond du Lac, Black Lake, and Southend respectively). These were evaluated for minor retrofits only.

1.3 Review of Alternate Energy Sources

Free energy from solar and wind devices were suggested as inadequate because they would not function when needed most, i.e., mid-winter during extreme sub-zero temperatures. Winds and solar energy potential were found to be relatively low during these periods in the northern latitudes of the study area.

Chunk wood is readily available and used extensively for home heating throughout the study area because it is mainly free for the labour. However, it has not been demonstrated viable for institutional utilization. The cost of supplying, storing, feeding and residual removal appears close to that of oil. This cost associated with, and the problems of, supply management (supply reliability) and encumbrance of the system weigh against this alternative.

The chipped wood option is faced with similar costs and management problems as the chunk wood alternative involved in the supply, chipping, storing, delivery, charging and residual removal.

A demonstration program of chip wood/oil dual fired furnaces is suggested in the recommendations.

Several mini-hydro prospects have been identified in the study, i.e., Woodcock Rapids between Black Lake and Stony Rapids and Whitesand Dam southwest of Southend as examples, however, none have been demonstrated to be economically viable.

Although some of the alternate energy alternatives are identified as technically feasible, none are identified as offering a convenient viable alternative to oil or propane fuels presently being used throughout the study area on the basis of present day costs. The possible development of a wood chip cooperative supply system for labour and management training for providing fuel to dual fuel institutional furnaces is reviewed in the summary section.

1.4 Energy Conservation Measures

Twenty-three (23) retrofits involving building envelope, mechanical and electrical system upgrading measures for the conservation of heat and electrical energy were identified on a unit basis, i.e., per furnace or per square metre basis, etc., and presented in a data sheet format.

The identified retrofit measures include the following:

	Building Envelope	Mechanical System	Electrical System
1.	Add Insulation to Exterior Walls		
2.	Add Insulation to Interior Walls		
3.	Add Attic Insulation		
4.	Add Flat Roof Insulation		

	Building Envelope	Mechanical System	Electrical System
5.	Triple Glaze Existing Double Glazed Windows		
6.	Vinyl Film Seal over Windows		
7.	Add Storm Door		
8.	Add Door Weatherstripping and Sweep		
9.	Add Vestibule Air Lock		
10.		Add Temperature Setback Thermostats	
11.		Revised Entrance Heating Outlets	
12.		Outside Air Control System Ventilation (furnaces)	
13.		Mixed Air Control System (Ventilation units)	
14.		Ventilation Unit Fan Control	
15.		Furnace Replacement with Condensing Furnaces	
16.			Flourescent Lamp Replacement with Econo-Watt Type Lamps
17.			Fluorescent Lamp and Ballast Replacement with Energy Efficient Units

Building Envelope	Mechanical System	Electrical System
		18. Replace Socket Incandescent with Socket Fluorescent
		19. Replace Incandescent with Fluorescent Fixtures
		20. Replace Exterior Incandescent with Sodium Vapour
		21. Change Exterior Par 150 Incandescent to Sodium Vapour
		22. Change Exterior MV to HPS Lamps
	23. Convert Diesel Generator Direct Drive Sheave to Electric Clutch	

The retrofit costs and the energy savings in terms of fuel and dollars and payback periods were identified for the respective options. Some of these had lengthy payback periods, i.e., greater than ten years, which were presented for information purposes. The retrofit data sheets were used in the building assessment reviews for identifying potential energy savings and retrofit costs for undertaking certain identified conservation measures. The retrofit costs (development shown) were taken for average northern conditions and not site specific to any one location.

The fuel costs used in the cost savings and payback determinations were rounded averaged figures for the study area ($.40/L oil and $.39/kW for power).

1.5 Building Assessments

Most of the buildings (67 of the 93) had prior energy audits performed either by Saskatchewan Power Corporation (29) under the Enersave(1)Mobile Energy Audits or by the National Research Council Hot Can Audits (38). Some of the structures were duplicates where one audit served two or more buildings.

The CEAP Audits in most cases identified what energy reduction and fuel cost saving could be achieved through implementation of certain insulation upgradings, exhaust volume reductions and lighting fixture changes without consideration for the retrofit costs and payback periods. The Hot Can Audits provide a calculated energy loss breakdown and compared this to the energy use and cost of an equivalent size Super Energy Efficient Home (SEEH) finished to the R2000 standard.

Those without energy audits were analyzed for energy loss breakdown.

Construction drawings of most of the major facilities were secured for reference purposes. An on-site examination of each building was undertaken by a two-man team for building and system familiarization to assess applicability of various retrofit options. The identified retrofit options either from the Enersave Studies and/or on-site assessments were then summarized in a building summary report. These reports reviewed the present energy consumption rates, identified potential savings by undertaking certain retrofits, the costs and paybacks of undertaking such retrofits, and indicated the respective payback periods. A separate Building Summary was prepared for each building and summarized in the summary and recommendations chapter.

1.6 Summary and Recommendations

The summary and recommendations are presented in two parts; one reviewing the alternate energy sources and the second dealing with energy conservation measures.

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(1) Performed Under
Canada Energy Audit Program (CEAP)

1.7 Alternate Energy Sources

The technical feasibility of using alternate energy sources is confirmed for chunk wood, wood chip, wood gasification and small scale hydro. However, it is identified that none of these options by themselves has been judged to be economically viable to the currently used fuel oil or propane for the institutional facilities studied. The alternates were identified as costly (hydro), costly and technically complicated (wood gasification) or inconvenient, and not economical enough to encourage its use (peat and chunk wood).

Wood chip was identified as having some potential for relatively automated dual firing application and, because of the manpower management for feed stock procurement and chipping operation, it lends itself to an alternate fuel industry and management training program in the form of a Band operated facility supplying wood chips to institutional faciliities under Contract for approximately $100/equivalent cord or $.36/L equivalent oil price. New school facilities are being proposed for Wollaston and Black Lake where current fuel costs are in the $.45/L range. These could be considered for dual fired wood chip/oil demonstration projects.

1.8 Energy Conservation Measures

Twenty-three retrofit measures were considered for the ninety-six institutional buildings in ten northern Saskatchewan communities. A breakdown showing the proposed retrofit measures for each building together with cost benefit data is noted in the building survey chapter and a summary for each building is presented in the summary chapter.

A potential energy saving of 215,827 gallons (981,171 L) per year (including diesel power generation allowance) worth has been identified with the retrofit options suggested. The retrofit costs are estimated at 433,092 dollars.

The Report is arranged so that the Chapters, Introduction, Energy Conservation Measures and Building Assessments can be excerpted in whole or in part for mini-reports for the responsible agencies for the respective institutional buildings to assist in their energy conservation programs.

ISLAND LAKE TRIBAL COUNCIL INC. RESIDENTIAL ENERGY AUDITS: ABSTRACT

This study funded by the Remote Community Demonstration Program of Energy Mines and Resource Canada, resulted in energy audits of 80 bungalows in four communities in the Island Lake Region of East-Central Manitoba.* On-site audits were carried out in December, 1984. The audits included visual inspection and measurement of dimensions, temperatures, relative humidity, wood consumption and flue gas composition (the last three items for selected dwellings only). Retrofit measures dealing with insulating attics and crawl spaces, re-skinning walls, and sealing were costed. Fuel savings were computed using the HOTCAN computer program with estimates of existing fuel wood consumptions used as energy control totals for each house. The results are presented for each house and are combined with a general approach to conserving energy and maintaining the dwelling stock. In addition a suggestion is made to provide adequate fresh air intake to allow moisture -laden stale air to be exhausted.

* The four communities are: Garden Hill, Red Sucker Lake, St. Theresa Point and Wasagamack.

ENERGY CONSERVATION FOR NON-RESIDENTIAL BUILDINGS

ARMSTRONG, ONTARIO

1. EXECUTIVE SUMMARY

This project was undertaken for the Armstrong Area Chamber of Commerce by Shelter Construction & Development Ltd. and Martin Associates Architects, with funds provided under Phase 1 of the Remote Communities Demonstration Program by Energy, Mines & Resources Canada. The purpose of the study was to assess the potential of non-residential buildings in the Town to accept energy conservation improvements designed to save fuel oil for space heating.

Armstrong, Ontario is a small community of 126 households with a population of 800, and is located approximately 250 km north of Thunder Bay. The Town is situated on the CN transcontinental rail line and is served by Highway 527.

Twenty non-residential buildings in Armstrong were assessed initially to determine their energy conservation potential. This initial sample represented all of the major building types in the community: hotel, multiple accommodation, commercial/retail, assembly, and public/government. From this list, four buildings: the District School Board Office, Armstrong Public School, the Royal Canadian Legion Hall, and J & J Hardware store, were selected for detailed analysis, using the National Research Council HOTCAN computer program for calculating building heat loss.

The buildings were photographed and measured, and subjected to door fan (air infiltration) and furnace efficiency tests where feasible. A set of possible improvements to the heating system or building components (roof, walls, windows, sources of air infiltration, etc.) was developed and costed for each building. Computer runs were done for each building to determine the resultant energy savings from introducing improvements one at a time. The improvements were costed and then ranked in approximate order of their cost effectiveness, for each building.

The general conclusions of the study are that energy conservation measures which are both feasible and cost-effective can be undertaken for each of the candidate buildings. Energy savings of 60% or higher can be achieved with measures having payback periods of about 5 years or less. Although the rankings of recommended improvements vary with each building, a general ranking of suggested measures, in order of their cost-effectiveness, emerged as follows:

- furnace tune-up and improvement
- reductions in air infiltration: weatherstripping, caulking, double-glazing, and related measures
- roof insulation (batts)
- wall insulation (batts).

Measures which were usually not cost-effective included rigid insulation applied to the roof or walls, insulated window shutters, and basement floor insulation.

In Armstrong, the results of the analysis suggest that as much as $140,000 or 36% of the community's fuel oil bill for space heating, could be saved annually, if every feasible non-residential building was upgraded to optimum levels. The capital costs for these improvements would range from $450,000 to $700,000. Local labour would represent approximately 40% of these costs, providing 10 to 20 man-years of employment.

The results of this study are felt to be applicable to other remote Ontario communities. However, detailed analysis would be required in each individual case, to account for intra-community variations in building construction and condition; as well as labour, fuel, transportation, and material costs; and to prepare an in-depth improvement program responsive to the needs of individual buildings and users.

ENERGY CONSERVATION THROUGH THERMAL UPGRADING OF BUILDINGS IN ATTAWAPISKAT, ONTARIO

EXECUTIVE SUMMARY

This study prepared by Scanada Consultants Limited and Con-Serve Group Limited evaluates and defines the potential for reducing the present space heating energy consumption for buildings in the community of Attawapiskat, Ontario. The study was supported by Energy, Mines and Resources (EMR) Canada's "Remote Community Demonstration Program". Careful field investigations of the buildings in the community and discussions with Chief John B. Nakogee and members of the Band Council preceeded the analysis and the development of suitable, energy conservation measures. Energy upgrades were defined to suit the specific requirements of a remote community. Appropriate materials, along with estimates of installed costs, and illustrated outlines of the installation methods have been outlined for each conservation method.

To help initiate the implementation of the suggested conservation measures, an overall plan was developed to link specific building groups with the required upgrade measures. Priorities were then established to pinpoint which groups were in greatest need of retrofit, and therefore where the cost-benefit would probably be the best.

Part of the technology transfer also included a review of the sources of funding available to assist in the execution of the desired energy upgrades. The community of Attawapiskat is well suited for the implementation

of various energy conservation measures. Its residential and commercial/institutional buildings presently have numerous energy weaknesses, but they can generally be corrected quite readily and in a cost-effective manner. Local construction people can effectively work with other members of the community to correct most of these deficiencies.

Several potential upgrade measures have been identified that are well suited to remedy the energy weaknesses in Attawapiskat. The potential measures are:

ECM 1: Wall Retrofit - Exterior Application
ECM 2: Wall Retrofit - Interior Application
ECM 3: Attic Insulation
ECM 4: Floor Insulation
ECM 5: Air Tightening Walls
ECM 6: Improve Heat Distribution
ECM 7: Window Replacement
ECM 8: Interior Storm Windows
ECM 9: Weatherstrip Windows
ECM 10: Storm Door
ECM 11: Insulated Door Cover
ECM 12: Metal Clad Insulated Door
ECM 13: Weatherstrip Doors

Upgrade measures have been recommended for each building group as stated in the "Implementation Plan". Virtually all of the homes require upgraded attic insulation and air tightening of the exterior walls. Window and door weatherstripping is required on all but the newest structures.

The total estimated cost of implementing all of the appropriate upgrade measures would be approximately $312,000.00. Based on calculated energy savings, these retrofits would save the community approximately 640 full cords of firewood per year. The community feels that a face cord is worth about $35, or $105 per full cord.

Implementation of the recommended energy upgrade measures would therefore save the community about $67,000 per year, resulting in a simple payback for the program of 4.5 years.

As energy conservation principles become more widely applied in Attawapiskat, other remote communities will hopefully become aware of the potentials to reduce energy consumption levels and to greatly improve comfort levels of their houses.

KATIVIK EFFICIENT ENERGY STUDY

An energy study and training program in Kuujjuaq and Kangirsuk, Quebec

Executive Summary

Kativik Regional Government and Makivik Corporation in northern Quebec decided in 1983 to undertake an energy planning study and training program for northern Quebec. Referred to locally as the Kativik Efficient Energy Program (KEEP), the study took place over 10 months in 1984 and 1985, with financial contributions from the Remote Community Demonstration Program of Energy, Mines and Resources Canada; Hydro-Québec; La Société d'Habitation du Québec; Kativik Regional Government, which managed the study; and Makivik Corporation.

Fourteen Inuit communities in northern Quebec, with populations ranging from 100 to 1,200, come under Kativik Regional Government. These 14 communities are also of concern to Makivik Corporation, an Inuit corporation set up to ensure that the James Bay agreement of 1975 is respected.

This Kativik study concentrated on two communities: Kuujjuaq, formerly known as Fort Chimo, (pop. about 1,200) was chosen as an example of a large centre; and Kangirsuk, formerly known as Payne Bay, (pop. about 300) represented an average-sized village. Both are located on Ungava Bay.

The largest energy consuming group in the communities is the residential energy sector, so the housing stock became the focus of the study.

The first task was to compile a data base on residential consumption of electricity and heating fuel. Limitations to the information presented and techniques used to estimate missing data are described. Household electricity and heating oil consumption patterns are graphically depicted for unrenovated, renovated and new buildings.

Domestic heating oil consumption and costs have decreased slightly over the past three years in Kangirsuk, and have increased by 9% a year in Kuujjuaq.

Domestic electricity consumption and costs have increased significantly in both communities. In Kangirsuk, household electricity consumption has gone up an average of 35% per year since 1982, and total costs have risen 58% per year. This is because of an increase in the number of houses. In Kuujjuaq, consumption has risen 10% per year, and costs, 22%.

The second task involved training. In fall 1984, five Inuit in the two communities participated in a four-month "on-the-job" training course which taught them to find energy losses in houses and how to remedy the situation. They learned about no-cost and low-cost energy conservation measures such as weatherstripping, caulking and glazing improvement. Consultants from the "south" (Montreal) supervised the training.

A total of 23 houses were retrofitted at an approximate cost, including manpower, of $675 per house. Monitoring of all the KEEP retrofitted houses in Kangirsuk for three months indicates the payback period is expected to be less than a year.

The report also discusses mini-hydro, tidal, wind and solar potential for both communities. The last three are considered possibilities, but would need much more investigation.

The study succeeded in its primary goal of developing people's awareness of energy and the need to conserve it. The "house doctors" played an important role in this respect. The study also demonstrated the ability of the local people to acquire the skills to improve their own housing conditions.

It should be noted that, even before the study was completed, it succeeded in interesting other people in the work. A third Kativik community, Tasiujaq (formerly known as Leaf Bay or Baie-aux-Feuilles), hired the consultant for a few days to explain the KEEP project and demonstrate some energy conservation techniques. During this time, two houses in Tasiujaq were weatherstripped and caulked.

The consultants hired to undertake the study were Memphremagog Community Technology Group and Chalifour, Marcotte et Associés Inc.

ENERGY MANAGEMENT SYSTEMS FOR WEMINDJI, QUEBEC

A STUDY OF AVAILABLE OPTIONS

1.0 SUMMARY

The electric supply to Wemindji has been the responsibility of the Department of Indian Affairs and Northern Development (DIAND). The electricity has been supplied by diesel generators and was intended to be used only for the Basic Electric Load (BEL). This is the load that must be supplied by electricity and includes lighting, motors, domestic appliances, etc. In contrast, the Space Heating Load (SHL) can be supplied by a number of energy sources including electricity, oil or wood. There has been considerable use of electric heating at Wemindji as is shown by the typical electric loads in winter which are far in excess of the summer loads, even though the BEL is assumed to be constant throughout the year.

Except for "Third Party Consumers", the consumption of electricity has not been monitored. There are no electricity meters in the homes and there has been no charge for electricity consumption. Within the community many homes are using "free" electric heating, by baseboard heaters, portable heaters or from the stove. There is no tradition of minimizing electricity consumption because of the availability of this electricity.

With the installation of the mini-hydro, the Wemindji community and DIAND will initially take joint responsibility for the electrical energy supply system within the village, including the operation of the mini-hydro and the diesel generators. Long term operation has yet to be decided.

The objectives of this study were to review the existing data on the forecast energy demand and the mini-hydro capacity and to study the options available to manage both the energy supply and the load demand within the community.

Different forecasts for the energy demand at Wemindji were reviewed and compared with the capacity of the Maquatua mini-hydro installation. It was demonstrated that there will be sufficient capacity to supply the BEL and all, or part, of the SHL throughout the year for a number of years in the future. However, there will be periods in the year when the high cost diesel generation must be used unless there is a careful control of electric space heating.

The primary function of the mini-hydro is to supply the BEL for the community, thereby reducing the consumption of oil for diesel generation. Excess mini-hydro capacity will be used to displace oil and wood heating if this does not reduce the capacity to supply the BEL. The mini-hydro generator power output is limited to 1 100 kW even with a full reservoir and maximum river inflow. Also, there will not be sufficient mini-hydro capacity in the winter months to meet the total community energy demand for BEL and SHL.

These operating conditions require a method of controlling the generation and the loads at Wemindji. An Energy Management System (EMS) is required:

- To ensure that there is sufficient mini-hydro capacity to meet the projected BEL demand for the next operating period
- To maximize the use of available mini-hydro energy and to avoid, where possible, the spilling of water
- To minimize the use of diesel generation
- To displace the use of oil heating as much as possible
- To ensure fair distribution of the "low-cost" mini-hydro heating energy within the community

Using predicted values for the mini-hydro capacity and for the community electrical load the following operating rules can be applied:

- E_{MH} is greater than (BEL+SHL): Electric heating will be supplied
- E_{MH} is greater than BEL but less than (BEL + SHL) : Limited electric heating will be supplied
- E_{MH} is less than (BEL) : No electric heating will be supplied

It will be necessary to manage the overall electric load within the community for several months of the year even in the early years. Later, load management will be essential year-round.

At the generating station there is no way of distinguishing between electricity used for BEL and electricity used for SHL. Some means must be found to control electrical heating at the consumer location and this applies to domestic, commercial or institutional consumers.

A number of management options are reviewed:

- No restriction in electricity consumption
- Domestic electrical heating in the summer and fall months only
- Voluntary switching of electric space heating
- Dual tariff electricity metering

- Automatic switching of electric space heating

At a general community meeting a number of EMS options were reviewed and discussed. It was decided that a voluntary EMS would be adopted and that, when necessary, the domestic consumers would switch from electric heating to wood or oil when requested to do so by the operators.

The first period of operation for the first few months until early summer, 1985, will be non-typical. Winter commissioning of the mini-hydro has resulted in the presence of downstream ice which reduces the maximum power output of the mini-hydro to approximately 600 kW. This coincides with the period of minimum energy capacity due to the reduced river inflow. Also, it is not possible with the present temporary arrangement to synchronise the existing diesel generators onto the system with the mini-hydro connected. These difficulties will be removed from mid-May onwards, but until that time the diesel unit will be permanently connected to the system and will supply the difference between the total community demand and the mini-hydro output. There may therefore be a greater consumption of diesel fuel than would be expected in later years.

The second period will be the first full operating season from summer 1985 to summer 1986. By this time the combined mini-hydro/diesel powerhouse will be commissioned and the operators will be familiar with the techniques of managing the mini-hydro output, forecasting load demands and controlling the electric heating load. The community will have gained experience in the voluntary control of electric heating and with the requirement to switch to oil or wood when required. Following this period, the EMS will be reviewed by the Management Committee to determine if any changes are required.

ENERGY STUDY

FOR WEYMONTACHIE AND OBEDJIWAN, QUEBEC

Executive Summary

The Attikamekw-Sipi Coordinating Committee hired the SNC Group to conduct an energy study for the communities of Weymontachie and Obedjiwan.

The study, carried out between October 1983 and April 1984, involved:

- Evaluating the energy situation in each community;
- Evaluating the energy conservation potential;
- Forecasting energy demand for the next 5, 10, 20 and 30 years;
- Considering potential energy sources; and
- Evaluating the economic feasibility of possible energy sources over next 5, 10, 20 and 30 years.

Consumption

Energy consumption of homes and public facilities in each community was determined. (Other energy consumers, such as vehicles and electrical tools, account for less than 1% of total demand.) The base electrical load (BEL) includes all electrical demand except for heating. The heating load (HL) was established after conducting energy audits of sample buildings.

The energy demand for the year 1983-84 is estimated to be:

	WEYMONTACHIE			
	Houses		Public Buildings	
BEL:	770 MWh	185 kw	200 MWh	70 kw
HL:	6,400 MWh	1,400 kw	900 MWh	200 kw

	OBEDJIWAN			
	Houses		Public Buildings	
BEL:	990 MWh	280 kw	270 MWh	95 kw
HL:	11,050 MWh	2,500 kw	1,350 MWh	300 kw

The demand forecast for the next 5, 10, 20 and 30 years is related to:

- Rate of population growth (2.4%/year during the next 30 years);
- Reduction in the home occupancy rate (to six people or less); and
- Communities' building expansion plans.

Demand over the next 30 years is estimated to be:

	WEYMONTACHIE					
	BEL		HL		TOTAL	
YEAR	ENERGY (MWh)	DEMAND (kW)	ENERGY (MWh)	DEMAND (kW)	ENERGY (MWh)	DEMAND (kW)
1983	970	255	7,300	1,600	8,270	1,855
1988	1,500	400	13,000	3,000	14,500	3,400
1993	1,700	500	14,600	3,200	16,300	3,700
2003	2,200	600	18,800	4,200	21,000	4,800
2013	2,700	700	23,700	5,400	26,400	6,100

	OBEDJIWAN					
	BEL		HL		TOTAL	
YEAR	ENERGY (MWh)	DEMAND (kW)	ENERGY (MWh)	DEMAND (kW)	ENERGY (MWh)	DEMAND (kW)
1983	1,260	375	12,400	2,800	13,660	3,175
1988	2,314	636	23,200	5,200	25,514	5,836
1993	2,656	726	26,500	5,900	29,156	6,626
2003	3,442	892	34,000	7,700	37,442	8,592
2013	4,460	1,120	43,700	9,800	48,160	10,920

Most of the older houses in both communities are in poor condition and badly insulated. The supporting walls are ripped and the plumbing which goes through uninsolated wall areas is of no use when it freezes. Most of the newer houses have cracks in the foundations and ought to be abandoned unless they are repaired. The cost to retrofit to super energy efficient (R-2000) standards is estimated at $20,000 per house. This would result in at least a 50% reduction in heat consumption, while increasing the comfort.

By themselves, energy savings do not justify the cost of retrofits. However, if retrofitting is not done, the oldest houses will be much less comfortable than new homes and will rapidly be abandoned.

Options

The study reviews the following energy sources:

- Diesel-generated electricity (considered only for the BEL need);
- Heating oil (considered as a supplement to other, more economical methods of heating, such as wood or mini-hydro);
- Solar (considered only for production of domestic hot water. The system studied is a device installed on the roof of each house in order to transmit electric heat);
- Connection to the Hydro-Québec power grid (considered in terms of connection at the nearest point. For Weymontachie, this is Rapide Blanc, 75 km; for Obedjiwan, it is Chigoubiche, 130 km). The costs are based on evaluations in similar regions. Connection to the Hydro-Québec power grid would meet the electricity and heating needs for the next 30 years and more.
- Wood (logs and chips). (A study of nearby forest reserves concludes that they are sufficient for the next 30 years.)
- Mini-hydroelectric plant. There are two areas near Weymontachie favourable for the construction of a small hydroelectric plant. The first includes two potential sites on the Allard Rapids on the St-Maurice River, 6 km downstream from the village. Technical and cost criteria favour the construction of a power-station with an installed capacity of less than 1,500 kW at the first site and more than 1,500 kW at the second. The second area is on the Manouane River, near the existing dam on the Chateau Vert reservoir, 21 km upstream of Weymontachie. Total cost of hydroelectric plants on the Manouane River exceeds the costs associated with the sites on the St-Maurice River.

  In the immediate area of Obedjiwan, only one site is favourable for a mini-hydro plant. The site is 7 km north of Obedjiwan, at the outflow of Lac Gaudet. Annual electricity production is forecast to be sufficient to satisfy the entire BEL demand and a substantial part of HL demand until 2013.
- Wind. After a preliminary evaluation, wind energy was excluded from the analysis. It is too costly, given the wind resource and energy needs at Weymontachie.

Supply options are:

Option A: BEL diesel
HL heating oil and wood logs (0 - 100%)

Option B: BEL diesel
HL biomass (wood chips)

Option C: BEL mini-hydro plant
HL mini-hydro plant, heating oil and wood logs (0 - 100%)

Option D: BEL mini-hydro plant
HL mini-hydro plant, biomass (0 - 100%)

Option E: BEL biomass (wood chips)
HL biomass (wood chips)

Option F: BEL hydro-Québec grid connection
HL hydro-Québec connection and wood logs (0 - 100%)

Option G: BEL mini-hydro plant
HL mini-hydro plant

In the first two options, the diesels will be replaced at the end of their lives and new diesels will be added to meet the forecast growth in energy demand.

Options B and E will have a standby oil heating system in case of a scarcity of wood chips.

For options C and D, the installed power of the mini-hydro plant depends on the results of an economic study and of available energy. It will meet the minimum BEL for the next 30 years.

It is believed that the normal rate for residential consumption would apply if the communities were connected to the Hydro-Québec grid.

Wood logs constitute the prime existing source of heat at Weymontachie and Obedjiwan. The logs are burned in traditional wood stoves. In all options, except those using wood chips, it is assumed that wood logs continue to represent part of the HL, particularly for older houses, since the price is relatively low, compared to other forms of energy.

For the last five options, the diesels are considered capable of providing the BEL if the primary energy source is unavailable. The lives of the diesels will certainly exceed the estimated period of 30 years.

Conclusions

At a discount rate of 7.5% during the next 30 years, two solutions are equally useful for Wemontachie:

- Construct a mini-hydro plant with an installed capacity of 250 kW to meet only the BEL;
- Continue to supply the BEL with diesel generators.

In both cases, heating would be by fuel oil and wood logs.

The mini-hydro plant would become the more economic solution if one of the following were to happen:

- The discount rate falls sharply below 7.5%;
- The cost of diesel fuel increases more quickly than general prices;
- The estimated cost of a mini-hydro plant is less than $5,040,000. A more detailed feasibility study, including a geological assessment of the site, would confirm the cost of the mini-hydro plant and determine the physical requirements.
- The construction cost of the mini-hydro plant is shared by the community of Saumaur, near Weymontachie, which also depends on diesels for its electricity.

Reducing labour costs (to isolate real expenditures by the communities) does not change the most economic solutions.

An additional economic evaluation has been completed to better understand the influence of different economic variables on the economic feasibility of the two most promising options for Weymontachie. A new planning period ending in the year 2033 is used. The influence of a nominal discount rate of less than 5% has been studied, as well as a fluctuation in the cost of logs for firewood and in the community's energy demand.

At discount rates below 10%, or when energy production is not limited exclusively to the burning of wood logs, the mini-hydroelectric plant is the more economical solution for producing energy until the year 2033, compared to the diesel plant.

At Obedjiwan, the current situation (diesel electricity and wood/oil for heating) is the most economical for the next 30 years. This is true regardless of possible variations in energy demand, discount rates, and usage of wood for heating.

The study was prepared for the Attikamekw-Sipi Coordinating Committee with contributions from Indian and Northern Affairs Canada and the Remote Community Demonstration Program of Energy, Mines and Resources Canada.

DESIGNS FOR ENERGY EFFICIENT HOUSING
IN NORTHERN MANITOBA

EXECUTIVE SUMMARY

The provision of housing on Indian Reserve communities is an urgent priority both for Indian organizations and the Federal Government (as represented by EMR, DIAND and CMHC) alike. As energy costs rise there will be an increasing need to construct well-designed, energy-efficient housing for Manitoba's remote Indian communities.

As a first step towards tackling the problem the Manitoba Keewatinowi Okimakanak Inc. (MKO) submitted a proposal for a programme consisting of two phases. Phase I is to design examples of more appropriate energy-efficient housing for the remote communities which fall under the jurisdiction of the MKO that is within the budget allotments available from DIAND and CMHC. Phase II will be to build the newly designed houses on a demonstration basis in a number of the new communities, and to develop an educational programme to promote the new designs and to teach techniques for constructing energy-efficient housing.

Phase I, in turn, is subdivided into three stages. **Phase I was undertaken in such a way to ensure maximum involvement by the communities and the MKO. The first is the Background Review Stage,** where the current housing designs, construction practices and the administrative problems and industrial benefits of delivering energy-efficient housing in the north were documented. The Design Team visited two of the four communities as part of the Background Review. In the **Preliminary Design, Stage 2, the Design Team prepared a series of concept plans** for presentation to the four remote communities of Brochet, Lac Brochet,

Pukatawagan and Tadoule Lake. The designs were then revised and a full set of 14 house designs were presented again to the four communities in the **Final Design, Stage 3.** The designs, while energy efficient, could not be done according to the Arctic Housing Standards because the current DIAND and CMHC housing budget guidelines do not permit the additional expenditure on extra energy conservation features.

The designs included bungalows, bi-level and 2 storey forms. They are listed as follows:

- Bungalow Plans
    1. 24' x 36' Plan "A" (3 bedroom)
    2. 24' x 36' Plan "B" (4 bedroom)
    3. 24' x 36' Plan "C" (3 bedroom)
    4. 24' x 28' Plan "A" (2 bedroom)
    5. 24' x 28' Plan "B" (2 bedroom)
    6. 24' x 28' Plan "C" (3 bedroom)
    7. 24' x 32' (3 bedroom)
    8. 24' x 40' (4 bedroom)
- Bi-level Plans
    1. 18' x 26' Plan "A" (3 bedroom)
    2. 18' x 26' Plan "B" (4 bedroom)
    3. 24' x 32' (6 bedroom maximum)
- 2 Storey Plans
    1. 16' x 28' (4 bedroom)
    2. 18' x 26' (4 bedroom)
    3. 20' x 24' (1 3/4 storey 4 bedroom)

The Phase I deliverables consist of this report on the project; 14 sets of house designs with construction details; bills of materials and current (March 1985) prices; two house models; model wall sections; a slide presentation; and the Background Review Stage report.

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ENERGY CONSERVATION OPPORTUNITIES, OIL SUBSTITUTION ALTERNATIVES AND IMPLEMENTATION STRATEGIES FOR COMMUNITIES OF THE WINDIGO TRIBAL COUNCIL, ONTARIO

EXECUTIVE SUMMARY

INTRODUCTION

This is the final report of a study carried out on behalf of the Windigo Tribal Council under the federal Remote Community Demonstration Program (RCDP). The study is entitled:

> Energy Conservation Opportunities and Oil Substitution Alternatives and Implementation Strategies for the Communities of the Windigo Tribal Council, Ontario

OBJECTIVES

The overall objectives of this study are:

- to identify, evaluate and rank energy conservation/oil substitution options available in the eligible Windigo Tribal communities;
- to prepare a detailed community energy plan for the community of Sachigo Lake as well as more general plans for each of the other eligible communities;
- to initiate a process of technology transfer to the communities of the Windigo Tribal Council.

SCOPE OF THE STUDY

The study's scope includes energy conservation/oil substitution options in three specific areas: Buildings; Heating systems; and Diesel electricity generation facilities. Alternative electricity generation options are not considered.

The primary focus of the study is the remote native community of Sachigo Lake. However, 5 additional communities within the Windigo Tribal Council were added to the study's initial focus. These communities include: Bearskin Lake, Weagamow (Round) Lake, Cat Lake, Muskrat Dam and Slate Falls (see Map #1 overleaf).

Site visits to each of these communities were carried out during the period January 9-17 (inclusive) 1984.

TECHNICAL OPTIONS ASSESSED

The study assessed seven specific technical options:

- new energy efficient housing including heating options
- upgrading of insulation, air tightness, and heating systems in existing housing
- upgrading of insulation, air tightness, and heating systems in Band-owned commercial buildings
- upgrading of insulation and air tightness in schools
- substitution of wood heating in schools and commercial buildings
- waste heat recovery from diesel power systems
- new energy efficient commercial buildings including heating options

COMMUNITY OBJECTIVES AND PRIORITIES

Table 1 presents a summary of the priorities assigned to each of the above options by each community. A scale of 0 to 5 is used; 5 indicates highest priority and 0 indicates no interest. The priorities assigned serve to emphasize the high level of concern given to more comfortable homes and buildings and to employment creation.

MAP # 1

WINDIGO STUDY
COMMUNITIES

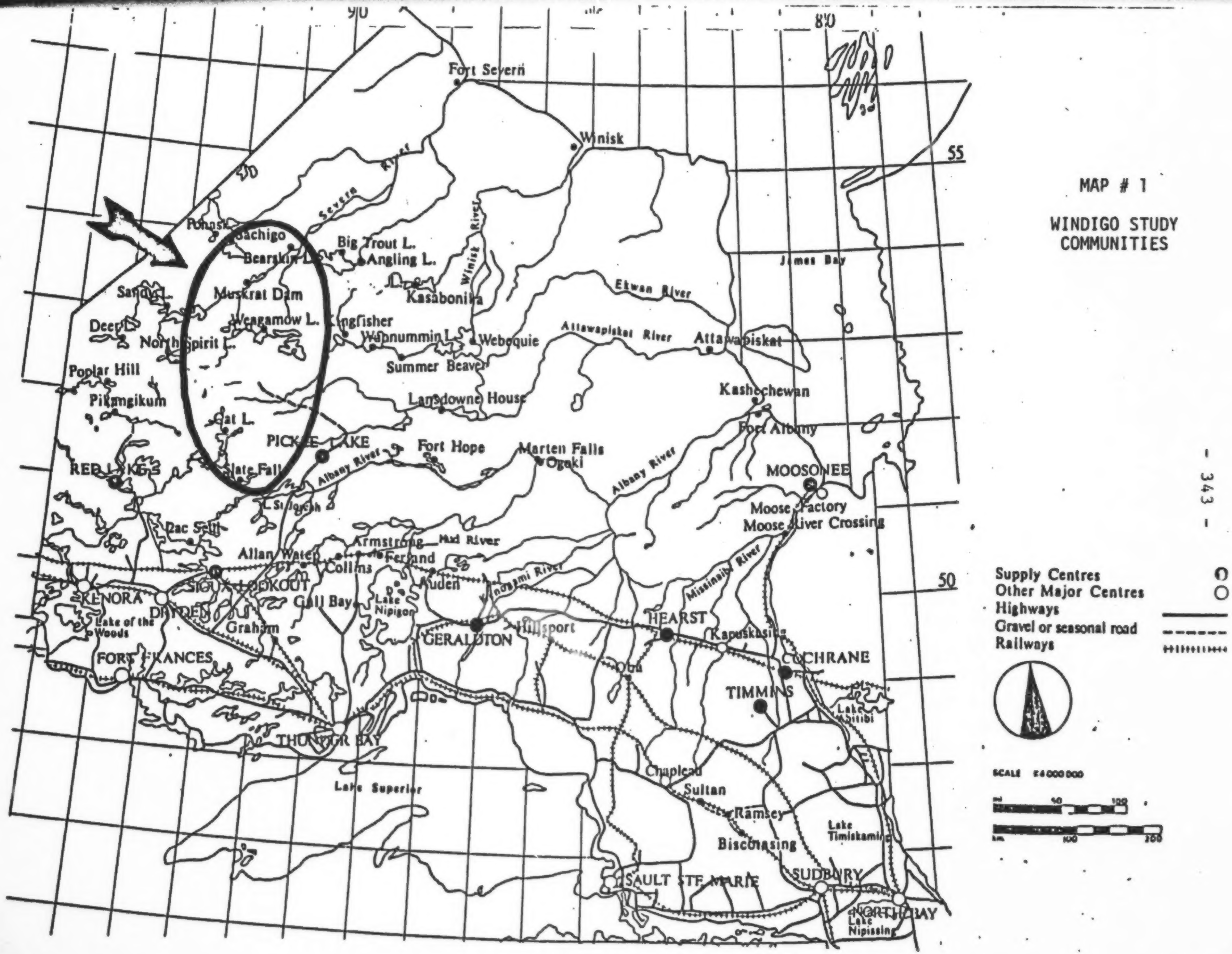

90
80
55
50
Fort Severn
Winisk
Severn River
Winisk River
James Bay
Ekwan River
Attawapiskat River
Attawapiskat
Kashechewan
Fort Albany
Albany River
MOOSONEE
Moose Factory
Moose River Crossing
Pohast
Sachigo
Bearskin L.
Big Trout L.
Angling L.
Kasabonika
Muskrat Dam
Wegamow L.
Kingfisher
Wapnummin L.
Weboquie
Summer Beaver
Lansdowne House
Sandy L.
Deer
North Spirit L.
Poplar Hill
Pikangikum
Cat L.
PICKLE LAKE
Fort Hope
Marten Falls
Ogoki
RED LAKE
Slate Falls
L. St. Joseph
Dac Seul
Allan Water
Armstrong
Mud River
Ferland
Collins
SIOUX LOOKOUT
Auden
Kenogami River
Missinaibi River
KENORA
DRYDEN
Gull Bay
Lake Nipigon
Lake of the Woods
Graham
GERALDTON
Hillsport
HEARST
Kapuskasing
COCHRANE
FORT FRANCES
Oba
TIMMINS
Lake Abitibi
THUNDER BAY
Lake Superior
Chapleau
Sultan
Ramsey
Biscotasing
Lake Timiskaming
SAULT STE MARIE
SUDBURY
NORTH BAY
Lake Nipissing
Supply Centres
Other Major Centres
Highways
Gravel or seasonal road
Railways
SCALE 1:4 000 000
mi 50 100
km 100 200

Table 1
COMMUNITY PRIORITIES

Community	New Housing (A)	Existing Housing (B)	Band Commercial Bldgs (C)	School Insulation (D)	School Wood Heating (E)	Diesel Waste Heat (F)	New Commercial Bldgs (G)
Sachigo Lake	5	1	2	3	5	1	4
Bearskin Lk	5	3	4	3	5	4	4
Weagamow Lk	5	2	4	3	5	4	4
Cat Lake	5	2	1	1*	4	3	4
Muskrat Dam	5	2	1	1*	5	3	4

* These are newer schools.

STUDY FINDINGS AND RECOMMENDATIONS

The major study findings and recommendations related to each of the above options are presented below:

A. **New Housing:** The report presents 4 new housing designs. Each design incorporates energy efficiency considerations and features which generally make the house more compatible with northern lifestyles. The estimated materials and labour costs for the four new houses range from $34,000 to $53,000. Three of the 4 designs are estimated to cost $42,000 or less and therefore can be constructed within existing DIAND allocations. Based on the results of the HOTCAN computer heat loss analysis, annual space heating requirements are estimated to be about 25% of current requirements.

The report recommends that the existing community new housing programs incorporate new energy efficient house designs and construction techniques as quickly as possible. A detailed implementation plan is presented. The major emphasis of the implementation plan is the provision of technical training to local residents in energy efficient construction techniques.

B. Upgrading Existing Housing: The report recommends three groups of retrofit measures for existing housing: upgrading of attic insulation; air sealing; and installation of efficient radiant heat airtight wood stoves. Detailed specifications for the application of each retrofit measure are provided including numerous line drawings. Some homes have already installed efficient wood stoves and Class-A prefabricated chimneys. In these homes, weatherstripping and air sealing material costs are estimated to be $250 plus transportation. If a new wood stove and chimney is required, an additional retrofit cost of about $1,000 plus transportation is estimated. Implementation of the range of recommended retrofit measures is expected to reduce wood consumption by up to 50%. The retrofit measures will also reduce uncomfortable drafts and help to extend the life of the building by reducing moisture damage. Two alternative implementation plans are outlined.

C. **Upgrading Existing Band Buildings:** The band offices in Bearskin Lake and Weagamow Lake were the two band owned buildings where the greatest interest and opportunity for retrofit measures were noted. In the Bearskin Lake band office, uninsulated warm air distribution ducts running through the attic and the lack of any ceiling in the furnace room results in very significant heat losses and poor heat distribution. Further, a new wood furnace has been installed beside the oil furnace but due to improper installation, it is inoperable. Recommended remedial measures for the existing oil furnace are estimated to reduce fuel oil consumption by 40-50% for an annual saving of about $2,000 (at present fuel prices). Further savings are possible by making the wood furnace operable and substituting locally purchased wood fuel for oil.

The Band office in Weagamow Lake is a two-storey log building. It is currently heated by two barrel stoves, centrally located on each floor. These stoves do not provide comfortable or efficient space heat:

- they burn down quickly at night, resulting in the building being very cold each morning
- it is difficult to control their heat output, resulting in frequent over-heating of parts of the building
- hot air distribution is inadequate, resulting in some portions of the building being overheated while other portions remain too cold.

The recommended remedial actions involve the installation of new efficient radiant heat wood stoves and the installation of circulating fans. These measures are expected to reduce wood fuel consumption by 50% and greatly increase comfort.

D. **Upgrading School Facilities:** A detailed energy audit was performed on the school at Sachigo Lake. Schools in the other communities were inspected but in less detail. Based on the results of the energy audit, the report presents specific retrofit measures. These include upgrading attic insulation to at least RSI 7 (R40) and performing specific air sealing measures. Detailed specifications and application procedures are presented for each recommended measure. Estimated retrofit costs for the Sachigo school are about $3,700 and are estimated to reduce annual fuel oil consumption by about 28% (or $3,600 at present prices). The payback period is therefore about 1 year.

At the present time, the maintenance and/or upgrading of school facilities remains a DIAND responsibility. DIAND has already initiated a program for upgrading the energy efficiency of many of its schools. It is expected that the detailed specifications provided in the report will assist them in their efforts.

E. **Substitution of Wood for Oil in School Heating Systems:** The school at Sachigo Lake is heated by an oil-fired boiler which is scheduled for major renovations or replacement in the near future. The report recommends that Sachigo initiate discussions with DIAND aimed at ensuring that when renovations occur, the existing oil boiler is replaced by a dual-fuel (wood/oil) boiler. Incremental costs for a dual fuel rather than an oil boiler are estimated to be about $5,000 for the heating system and about $5,000 for required modifications to the boiler room. Implementation of this option is expected to displace 15,000 litres of fuel oil annually and require the substitution of approximately 35 cords of wood. Assuming the current price of fuel oil (65¢/litre) and a wood price of

$150/cord, annual savings are about $4,500. Two permanent part-time local jobs would also be created. The simple payback period is 2.2 years at Sachigo Lake. Recommendations are presented for each of the other communities and similar (or shorter) payback periods are expected. The communities of Muskrat Dam and Slate Falls already have wood heating systems installed in their schools.

F. **Heat Recovery from Community Power Systems:** Weagamow Lake is the only Windigo community currently served by a community power system. In Sachigo Lake and Bearskin Lake, community power is in the final stages of installation. Cat Lake and Muskrat Dam do not yet have community power but expect to receive service within the next 5 years. No community power is currently scheduled for Slate Falls.

There are specific opportunities in Bearskin Lake and Weagamow Lake for the use of heat recovered from community power generators. In Bearskin Lake, there are plans to build a community economic development centre close to the new community power generator building. There will be a year-round demand for hot water in the centre for a laundromat and fitness centre which could be supplied in part by heat recovered from the community power generators. In Weagamow Lake, there are plans to build a garage/warehouse building near the airport. There will be a seasonal space heating demand in both buildings which could be met by heat recovered from the community power generators. At present these new facilities, in both Bearskin Lake and Weagamow Lake are at a preliminary stage of development. Final site selection, building design specifications and economic feasibility have to be established. Consequently, the Study Team could provide only general cost estimates.

On the basis of the data provided for the Bearskin Lake facilities, the installation of a waste heat recovery system is estimated to cost in the range of $100,000. Annual savings are estimated to be about $24,000 in projected propane consumption for hot water heating in the community development centre. The simple payback period is therefore about 4 years. The proximity of the centre to the existing diesel sets will be one of the most critical factors affecting economic feasibility.

On the basis of the data provided for the Weagamow Lake facilities (an 1800ft^2 warehouse and 2500ft^2 garage) the installation of a waste heat recovery system is estimated to cost in the range of $65,000. Annual savings are estimated to be about $10,400 against an oil space heating system and about $6,800 against a wood space heating system (at $150/cord). The simple payback against oil is therefore about 6 years and about 9.5 years against wood.

Community power in Cat Lake and Muskrat Dam has not yet reached the design stage. This means that the location of the diesel sets has not yet been fixed. Both communities are also in the midst of community planning projects in which separate areas of the community are being designated respectively, as residential and institutional/commercial zones.

The report strongly encourages both communities to consider the future location of their community power systems within their present community planning process. The report recommends that a central location within the planned institutional/commercial zone be established for the future community power system. This will maximize the future potential use of waste heat for the heating of new schools, stores, health centres, etc.

G. **New Commercial Buildings:** New commercial buildings are being planned in many of the Windigo communities. Most of the buildings will be single storey wood frame structures with floor areas between 100 and 400m^2 (1100 to 4300ft^2). Opportunities exist to construct these new commercial buildings to energy efficiency standards almost as high as can be obtained in new housing. Specific construction features that should be used in these new buildings are outlined.

It is estimated that incorporation of the recommended construction features will reduce annual space heating requirements for commercial buildings (schools, stores, etc.) from the present average of about 1.5GJ/m^2 (60 litres of oil/m^2/year) to about 0.75 GJ/m^2. The payback period for the addition of energy efficiency construction features will generally be less than 1 year.

COMMUNITY ENERGY PLANS

A community energy plan is presented for each community and considers:

- the feasibility of the identified technical options
- community objectives/priorities
- RCDP objectives of reduced fuel oil consumption
- timing and community resources

Options are recommended for both short term and longer term applications. Short term options are those considered ready for immediate action; longer term options are indicated where significant potential benefit exists but local conditions (ie, stage of planning) are not yet at a stage for immediate action.

Nonetheless, consideration of these longer term options should be incorporated into future community plans.

In accordance with the scope of the study, the community of Sachigo Lake is emphasized.

STUDY CONCLUSIONS

The report concludes that implementation of the technical options presented within each of the community energy plans will not only result in significant energy savings but also will contribute to more comfortable living conditions and local employment development.

SECTION 4

ENEROPTIONS CASE STUDIES

ENEROPTIONS CASE STUDIES:

- Remote Photovoltaics - Yukon 12
- Pelly Crossing Wood-chip Furnace - Yukon 17
- Residential Retrofit of Senior Citizen Housing - Yukon 20
- Skookum Jim Friendship Centre - Yukon 21
- Lac La Martre School Waste Heat Recovery - N.W.T. 12
- Super Energy Efficient Arctic Row Housing - N.W.T. 17
- Snowshoe Inn Ltd. Waste Heat Recovery - N.W.T. 18
- Wood Heating of Fort Smith Water Supply - N.W.T. 21

ENEROPTIONS CASE STUDY

YUK 12

Remote Photovoltaics

TOTAL NORTH COMMUNICATIONS

Technology:
Solar powered (photovoltaic) remote VHF repeater stations

Demonstration Project Manager:
Mr. Gordon Duncan
General Manager
Total North Communications Ltd.
311 Black Street
Whitehorse, Yukon
Y1A 2N1

Location:
3 remote mountain sites in the Yukon and in northern British Columbia

Annual Savings: $6,400 in helicopter service costs
84% of helicopter service costs for conventional system

Payback Period: 1.7 years

Applicable to:
A wide variety of remote radio repeater installations, such as —

- telecommunications
- remote meteorological data collection
- forestry services
- mining exploration
- navigation aids

Description:
Total North Communications Ltd. has successfully stepped into the solar age with the installation of three 75 peak watt photovoltaic (PV) systems with lead calcium battery storage at three mountain top locations in the Yukon and in northern British Columbia. The PV systems were used instead of conventional battery systems at these sites which serve as "line of sight" VHF repeater stations for seasonal mining exploration operations. The lead acid batteries in the conventional stations have to be "swapped out" by helicopter once every two or three weeks — at a cost of $400 to $600 per visit.

The three PV systems have operated reliably for two seasons. Although the direct energy savings are minimal, the maintenance cost savings have been very significant. Site visits, by helicopter, have been reduced from once every two to three weeks to once a season.

Benefits:
The major benefit has been reduced maintenance costs. As a result of the reliable performance of the PV systems, helicopter time for site visits has been reduced by about 16 hours per year — a savings of $6,400. Indeed, it is unlikely that these three communication installations would have taken place if it weren't for the maintenance savings possible through the use of PV power sources.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Performance:

The equipment, originally installed in summer 1982, has performed above expectations and has proven to be very reliable over several seasons. The panels have shown no sign of deterioration either physically or in terms of performance, despite being subject to very severe climatic conditions. The original mounting arrangement was suitable in terms of wind loading and ease of installation but proved to be unsatisfactory for snow and ice conditions. Snow and ice collected on the panel during the low or no light hours and, when melting occurred, the snow and ice would slide off in sheets and obscure the bottom of the panels. This condition degraded the cells' ability to produce electricity. This problem was resolved by changing the mount to allow a free space between the panels and the ground equal to the maximum snow depth plus 1.5 times the panel height. This allowed the snow and ice build up to fall freely from the panel.

Lead acid batteries were originally used for storage but, after one season, it was clear that they did not have the ability to handle the discharge/charge cycle of the PV system. Once the batteries dipped below one half of their rated output they did not recover, regardless of the charge which was applied. The lead acid batteries were replaced with lead calcium batteries, which have performed well.

Lead calcium batteries provide three important advantages:

- they are a sealed unit — no dangerous gases are produced and no corrosive acid is present
- they are better suited to the charge/discharge cycle associated with the PV system
- they have superior cold weather performance and are not susceptible to freezing.

The PV systems operated efficiently with a duty cycle of 5% to 10%. One site was found to be in heavier use than estimated and an additional solar module was added to prevent deterioration of signals from peripheral areas.

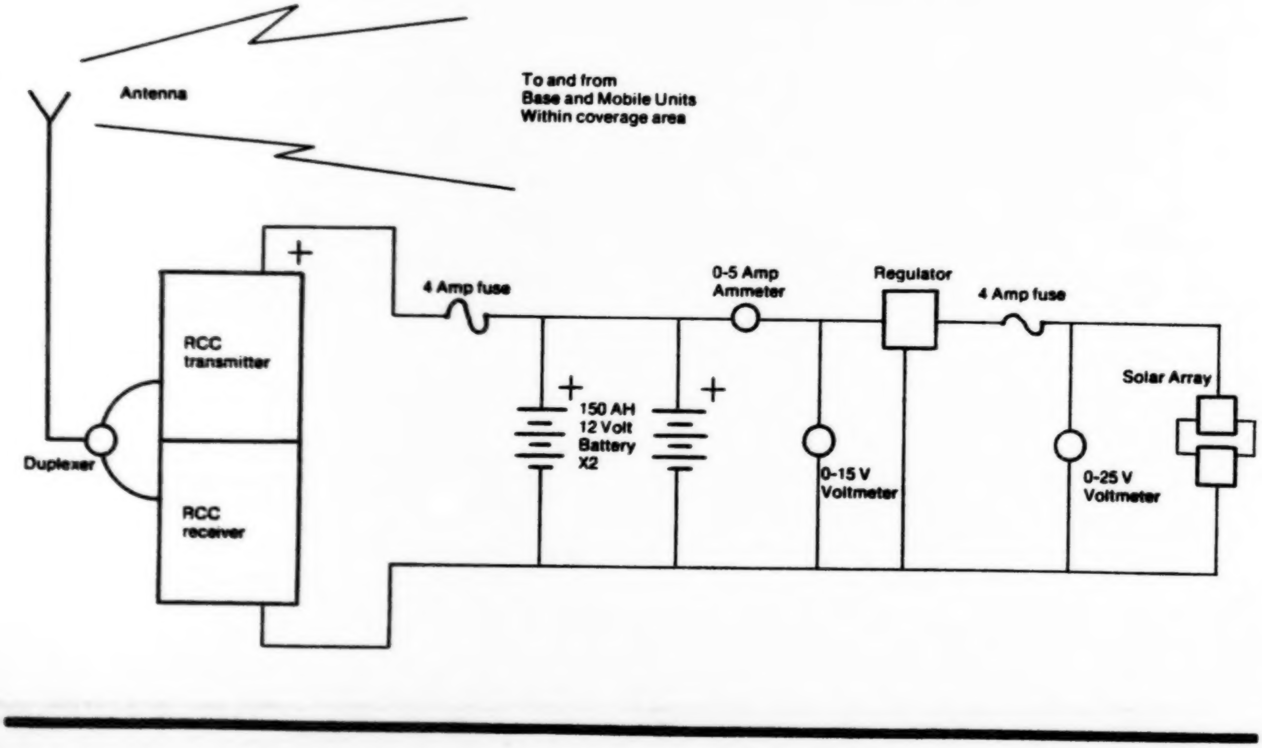
Technical Details:

In order to gain maximum coverage from the repeaters, all equipment was located on the vantage point of each of the mountains.

The electronics and batteries were housed in an enclosure constructed of 2 cm (3/4 in) plywood laminated with fibreglass. The PV panels were attached to the enclosure by an angle iron and were originally mounted directly to the side of the housing with angle iron brackets. The original mount was subsequently changed to allow additional snow and ice clearance.

Two types of PV panels were used — American manufactured ARCO 2300 panels and Canadian TPK panels. The ARCO panels used 10 cm (4 in) diameter cells while 5 cm (2 in) diameter cells were used in the TPK panels. The larger ARCO cells result in a greater density and 16% to 33% greater efficiency.

The solar modules powered two CGE mobile radios which were modified for repeater operation. The modifications consisted of the reduction of transmitter power and the interconnection between the transmitter and the receiver. The mobile repeater configuration was in-line rather than the conventional back-to-back. The figure presents a schematic of one of the sites.



Economic Analysis:

Project Capital Cost

PV panels	$4,669
Regulators	1,224
Misc. hardware	830
Replacement batteries & freight (lead calcium)	985
Total Capital Cost	$7,708
Installation	3,510
Total Installed Cost:	$11,218

Annual O & M Cost and Savings

Pre-demonstration helicopter time (19 hrs @ $400)	$7,600
Post-demonstration helicopter time (3 hrs @ $400)	1,200
Net Annual Savings:	$6,400

Simple Payback Period: 1.7 years.

Availability:

The demonstration units were designed and installed by Total North Communications Ltd. of Whitehorse, Yukon.

PV panels are available throughout Canada from major suppliers of solar equipment.

Further Information:

A final technical report on this demonstration is available from:

- ENEROPTIONS
  Energy Branch
  Department of Mines and Small Business
  Government of Yukon
  P.O. Box 2703
  Whitehorse, Yukon
  Y1A 2C6
  (403) 667-5382

Further information is also available from the demonstration project manager:

- Mr. Gordon Duncan
  (re: ENEROPTIONS)
  Total North Communications Ltd.
  311 Black Street
  Whitehorse, Yukon
  Y1A 2N1
  (403) 668-5175

ENEROPTIONS CASE STUDY YUK 17

Pelly Crossing Wood-Chip Furnace

Technology:
Automatic wood-chip boiler

Demonstration Project Manager:
Mr. Al Fedoriak
Maintenance Division
Department of Education
Government of Yukon
P.O. Box 2703
Whitehorse, Yukon
Y1A 2C6
(403) 667-5143

Location:
Pelly Crossing, Yukon

Annual Savings: $11,425
60% net savings on cost of oil heating

Payback Period: 11 years

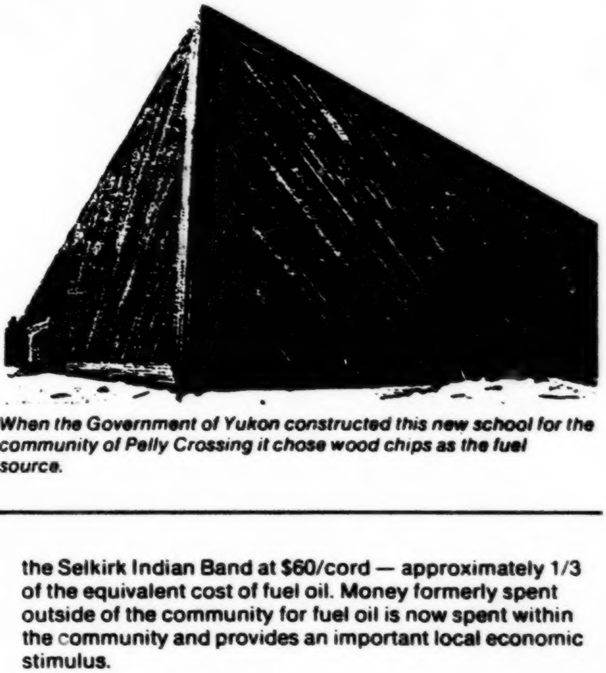
Applicable to:
Space and hot water heating applications in remote communities —

- Schools
- Hospitals
- Commercial buildings

Description:

A wood-chip heating system in the new school is saving oil and money, utilizing a local resource and providing employment in Pelly Crossing — a small, relatively isolated and predominantly native community approximately 280 km (175 miles) north of Whitehorse, Yukon.

In 1980, approval was received to build a new 1,300 m² (14,000 ft²) school which was also to serve as a community and recreation center. In the original design, the Eliza Van Bibber School was to be heated by two oil-fired boilers. However, in the final design stage a wood-chip heating system, providing both space heat and domestic hot water, was selected as a substitute for the oil system. The biomass system consists of a 350 kW Vyncke wood-chip boiler, an underfed stoker, and a 50 m³ (1,765 ft³) silo. Chips are provided from local fire-killed wood using a Bruks wood chipper powered by a diesel tractor. Backup is provided by a boiler and a domestic water heater, both fired by propane.



When the Government of Yukon constructed this new school for the community of Pelly Crossing it chose wood chips as the fuel source.

Benefits:

- The net annual savings from the wood-chip heating system appear to be $11,425 (1984), equivalent to 60% of the cost of operating a conventional, oil-fired system.
- The wood-chip heating system provides significant local economic benefit. Local cordwood is purchased from the Selkirk Indian Band at $60/cord — approximately 1/3 of the equivalent cost of fuel oil. Money formerly spent outside of the community for fuel oil is now spent within the community and provides an important local economic stimulus.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

- The harvesting and chipping of wood has created two local part-time jobs in a community of about 200 plagued by chronic unemployment.
- Both the local wood fuel supply and the wood-chipping system have considerable unused capacity. Further applications of wood-chip heating, as a substitute for conventional oil heating, are being pursued within the community. When implemented, these will further contribute to the local economy by reducing fuel costs, increasing local disposable incomes and creating additional employment.

Performance:

The system is now operating consistently and efficiently. Performance data are being collected and the results of a complete year's operation will be available by June 1985.

The approximate price of delivered heat from fuel oil (@ $0.46/litre) was estimated to be $20.10/GJ, or $19,295 annually (1984). Preliminary estimates indicate that the comparable cost using local wood chips is $8.20/GJ, or $7,870 annually based on: $60/cord for the harvested wood; $1,500 for labour and $450 for operation and maintenance of the chipper; $1,000 for propane backup; and $120 for electricity to power the augers. The 1984 net savings are therefore estimated at $11,425.

During the first few months of operation, a variety of technical problems were encountered. Although the problems were relatively minor they were exacerbated by the lack of technical services available within the community and by the community's remote location. Technical problems were encountered in the following areas:

- wood chip blockages in the auger system
- excessive exhaust fan noise
- system controls

In its initial operation, frequent blockages occurred at the first transfer point in the auger system. These blockages occurred as a result of oversized chips or splinters and the design of the transfer point. During one such incident, the auger itself was damaged. The blockage problem at the first transfer point was overcome by replacing the original corrugated metal sleeve with an angled sleeve made of metal on three sides with a plexiglass front. Greater attention was also paid to achieving uniform chip size. A slip clutch was also installed to prevent damage to the auger or motor in the event of future blockages.

Excessive fan noise was remedied by decreasing the speed of the forced draft fan. This also brought the air supply more in line with optimum levels and increased the overall boiler efficiency.

One of the boiler's safety controls created a minor problem. A sensor located upstream from the exhaust fan measures the flue gas temperature and, if the exhaust temperature is too low, the sensor automatically shuts down the boiler after 25 minutes of operation. The sensor which was installed initially had too high a temperature range and caused the boiler to shut down frequently. A new sensor with a proper temperature range will eliminate the problem.

Technical Details:

The school is a 1,300 m², (14,000 ft²) single-storey building of slab floor construction (built in 1982). In the interests of thermal efficiency, it includes roof insulation of RSI 9.2 (R 52), wall insulation of RSI 3.5 (R 20) and triple-glazed windows. The designed space heating temperature is 21° C (70° F) during occupied hours and 13° C (55° F) during setback hours. The total space heating and domestic water heating requirements are about 960 GJ per year.

Local fire-killed timber is harvested as cordwood by members of the local Selkirk Indian Band and is then chipped on site using a Bruks MTH922 wood chipper powered by a 40 hp John Deere 1040 diesel tractor.

The chips are fed into a 50 m³ (1,765 ft³) underground concrete silo, which provides storage capacity for about 10 days during maximum demand periods. The silo is equipped with a heat loop (to prevent freezing) and a live bottom consisting of trapezoidal cylinders, which are pulled across the bottom of the silo by hydraulic pistons in order to supply wood chips to the first of three 30 cm (12 in) diameter fuel augers. A rotary air lock is installed at the second transfer point to prevent burn-back. Burn-back is also prevented by means of a supply of water which will flood the final auger housing should it attain unacceptably high temperatures.

The heating system — a 350 kW Vyncke model WW300S underfed wood chip boiler with automatic feed — was installed during the fall of 1982. Operation began in February 1983.

The boiler is a three-pass vertical fire tube unit, which can be fed either with wood chips through the underfed stoker, or manually with cordwood through its door. An oil burner can also be fitted to an alternate door, if desired. Draft is provided by means of a blower located at the top of the boiler immediately beyond the fire tubes. Fly ash passes from the hearth through the fire tubes and is removed in a cyclone located just beyond the blower. The blower and cyclone are constructed of heavy gauge metal to resist the abrasive action of the fly ash. The boiler is designed to operate with 80% excess air at a combustion temperature of 1,320° C (2,400° F) and with virtually 100% combustion efficiency. Efficient heat exchange is achieved both through direct radiation and through the vertical fire tubes. The exhaust gases exit the boiler at a fairly cool 150° C (300° F) and are relatively clean.

Both the air intake and auger speeds have been adjusted to deliver the maximum requirements of the building. In this manner, maximum efficiency can be achieved during the shoulder periods, when a reduced boiler output is needed. The boiler contains more than 3,000 litres (660 gallons) of water, which stores approximately 120 MJ of heat. This supplies the building's heat requirements between boiler cycles. During normal operation, the boiler runs for about 20 minutes and then shuts down until further heat is required. The hearth will maintain a fire for longer than 24 hours during periods of very warm weather.

Economic Analysis:

Capital Cost:

Vyncke Model WW300S	$ 77,500
Warranty	3,000
Concrete silo & modifications	20,489
Glycol heat loop	4,000
DHW heat exchanger	19,226
Boiler electrical and automatic controls	14,394
Markup	7,908
Miscellaneous	4,68
Sub total:	151,201
Credit (oil boiler and propane backup):	(28,340)
Incremental capital cost for wood-chip system:	122,861
Incremental costs of boiler installation:	5,000
Total Capital and Installation:	$127,861

Annual Operating and Maintenance Costs:

Estimated annual fuel oil savings (41,850 litres @ $0.461):	$19,295
Estimated (annual) wood heating cost:	
• 80 cords of wood @ $60	4,800
• chipper operation and maintenance	450
• labour for chipping	1,500
• propane backup	1,000
• electricity for auger operation	120
	($ 7,870)
Net Annual Savings:	$11,425

Simple Payback Period: 11 years.

Availability:

The system was designed, supplied and installed by Apsco Engineering. Automatic wood-chip heating systems are available through suppliers and consulting engineering firms in major centres throughout Canada.

Further Information:

An interim technical report on this demonstration project is available from:

- ENEROPTIONS
  Energy Branch
  Department of Mines and Small Business
  Government of Yukon
  P.O. Box 2703
  Whitehorse, Yukon
  Y1A 2C6
  (403) 667-5382

Further information on this demonstration project is available from:

- Mr. Jack Dueck
  (re: ENEROPTIONS)
  Apsco Engineering Ltd.
  P.O. Box 270
  Cremona, Alberta
  T0M 0R0
  (403) 264-1049
- Mr. Al Fedoriak
  (re: ENEROPTIONS)
  Maintenance Division
  Department of Education
  Government of Yukon
  P.O. Box 2703
  Whitehorse, Yukon
  Y1A 2C6
  (403) 667-5143

Residential Retrofit of Senior Citizen Housing

YUKON TERRITORY

Technology:
Major and minor retrofit of homes and apartments

Demonstration Project Manager:
Yukon Housing Corporation
303 Jarvis Street
Whitehorse, Yukon
Y1A 3H3

Location:
Throughout the Yukon

Annual Savings: total of $48,000 for 98 units: 10 to 65% of previous consumption

Payback Period: 3 to 15 years

Applicable to:
All single family homes and some types of apartments

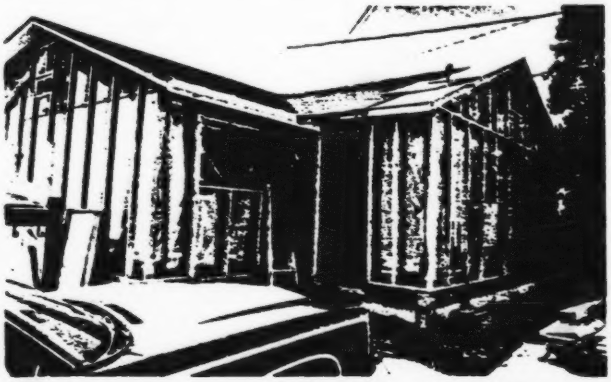
Description:

A wide range of residential retrofit measures were implemented in senior citizens' homes and apartments to demonstrate the cost-effectiveness of the measures.

Ninety senior citizens requested an energy audit of their homes and apartments and 56 agreed to retrofit. Four types of retrofit were carried out:

- low-level single home retrofit (caulking, weatherstripping and heating system upgrading)
- medium-level single home retrofit (more insulation, new windows and thermostats)
- major re-wrap retrofit of single homes
- minor and major apartment building retrofit

Each homeowner contributed an amount equal to the estimated first year savings towards the cost of retrofit.



Performing a total retrofit in Whitehorse — Curtain Wall approach.

Benefits:

- Space heating and water heating costs are significantly reduced for senior citizens.
- Home comfort is significantly improved (reduced drafts, improved humidity levels).
- Local contractors received training in energy efficient retrofit techniques.
- Emissions from wood stoves were decreased due to lower heating requirements.
- Over 20 medium and high level retrofits have taken place outside of the project as a result of project activities.

Performance:

Of the 235 senior citizens approached, 90 requested the free on-site energy audit—slightly lower than anticipated but still a large number to be handled by a single retrofit project. Of those audited, 56 agreed to have the retrofit work carried out.

Many of the homes were more than 20 years old and included a wide variety of building types. Several of the older homes were required to have complete re-wiring along with the retrofit package in order to meet electrical code requirements. However, the addition of curtain walls or Larsen truss walls to homes having a major retrofit did not require special municipal approval.

The level of interest shown by the senior citizens during the retrofit work varied considerably from house to house.

Seventeen journeyman carpenters or experienced contractors completed the 20 day training program in retrofit techniques. More than half of the graduates of the training course gained some work from the project. The requirement that contractors working on the project must complete the 20 day course was not universally accepted across the Territory. Several contractors felt they could not afford the 20 days of time. Enrollment in a special 3 day course arranged for these contractors and other interested persons was not as high as in the 20 day course and few of its graduates have participated in the program. The overall result of the training is that there are now several experienced retrofit contractors in the Yukon who are continuing similar work outside the project.

One source of delays in the project was the involvement of too many agencies in the administration of the project.

The energy audit and recommendations for retrofit were based on a site inspection and measurements followed by estimation of potential savings using the HOTCAN computer program. The 2-3 hour site visit was found extremely useful in showing the homeowner the benefits of a retrofit and in determining where extra time should be allowed for especially difficult retrofit work.

The computer program tended to exaggerate the potential savings that would result from a retrofit. This seemed to be due to the fact that in many of the homes it was difficult to effectively carry out the complete retrofit package because of inaccessible areas and the age of the house. Some contingency should have been included.

The retrofit specifications drawn up for bid on many homes were not detailed enough for accurate tendering. Contractors bidding for the first time on complex work such as house re-wrap required more detailed specifications. The actual retrofit work also required close supervision by the consultant making the recommendations to ensure quality workmanship.

Post-retrofit testing of air tightness and heating requirements was carried out on many of the homes. Air leakage was reduced by between 5 and 50% depending on the pre-retrofit condition and the type of retrofit carried out. Heating requirements were reduced as follows:

• Minor retrofits:	10-25% savings
• Medium level retrofits:	20-35% savings
• Major re-wrap retrofits:	40-65% savings

Monitoring of energy consumption will continue to provide more accurate assessment of the results.

Some homeowners complained of inadequate ventilation after the retrofit was complete. Most, however, were extremely satisfied with the results.

The major lessons learned from this extensive residential retrofit project appear to be:

- savings are less than predicted by the audit;
- retrofit costs are higher than projected—and substantially higher for the major retrofit work;
- payback periods are longer than expected for most levels of retrofit;
- major retrofits are not cost-effective on their own and are only economically justified if undertaken as part of necessary repair and renovation work on a building.

Technical Details:

The audience selected to participate in the project was the 235 recipients of the Pioneer Utility Grant — senior citizens eligible for assistance with utility payments. Letters were first sent out and were followed by personal phone calls.

Energy audits were carried out by a two person team which met with the homeowner and recorded information on house type, size, age, heating equipment, construction details, hot water use, number of occupants, and moisture levels. An infiltrometer was used to obtain an estimate of the size and location of air leakage.

Energy consumption was determined using the Enerkon and HOTCAN computer programs. Retrofit measures were drawn up for the house and the potential savings were estimated using the computer programs. Four types of retrofit packages were specified:

Group 1 Low Level Retrofit:
Caulking and weatherstripping of all accessible air leaks, oil furnace servicing, installation of hot water flow restrictors, storage blankets, and heating system timers.

Group 2 Medium Level Retrofit:
Group 1 measures *plus* upgraded attic insulation, new or upgraded windows, night set-back thermostats, and fresh air ducts into the furnace return air.

Group 3 Major Retrofit:
Group 1 and 2 measures *plus* complete rewrapping of the building envelope, new curtain or Larsen truss walls, air-to-air heat exchanger, and replacement of the heating system.

Group 4 Apartment Building Retrofit:
One apartment complex had a Group 1 and 2 retrofit on its main building (caulking, weatherstripping, attic insulation and a rebalanced heating system) and a Group 3 (external rewrap) on a smaller adjoining building. A second apartment had a complete Group 3 major retrofit including external re-wrap, a new roof, heating system replacement, and a ventilation/heat recovery system.

The work was carried out by local contractors who bid on specifications drawn up for each retrofit. Contractors were allowed to bid if they had CGSB certification to carry out insulation work and had completed the 20 day course in major retrofit put on under the project by Renewable Energy in Canada. To participate in the course a contractor had to be a journeyman carpenter or pass an entrance examination. A shorter 3 day course was also run for contractors unable to spend the 20 days required for the more complete course.

The project was administered by Yukon Housing Corporation. Other agencies involved included: the Energy Branch of the Department of Economic Development, which handled homeowner contacts and financing, the Department of Education which handled training, and the federal Conservation and Renewable Energy Office (CREO) which processed homeowner CHIP and COSP applications.

Homeowners were asked to contribute an amount equal to the first year's potential savings as predicted by HOTCAN but could reduce this through the use of CHIP and COSP grants.

Economic Analysis:

Capital cost of retrofits	
Homes (estimated)	$350,000
Apartments	$184,000
Total	$534,000

Annual Savings	
Homes (predicted)	$28,000
Apartments (predicted)	$20,000
Total	$48,000

Simple payback period: 11 years (on package of 56 buildings).

The range of costs and percent savings for each Group of buildings was as follows:

	Retrofit Costs:	Percent Energy Savings:
• Group 1: Low level retrofit	$500-$2,000	10%-25%
• Group 2: Medium level retrofits	$3,000-$4,500	20%-35%
• Group 3: Major retrofits (re-wraps)	$10,000-$18,000	40%-65%
• Group 4: Apartment retrofits	$24,000-$160,000	20%-65%

The cost of the training programs was approximately $60,000.

Availability:

All materials and specialized knowledge was obtained locally or obtained through the special training courses on retrofit measures. The courses were designed and taught by Renewable Energy in Canada, 334 King St. E., Suite 206, Toronto, Ontario M5A 1K8, (416) 363-9431.

Energy audits were carried out by Reid Crowther and Partners Ltd., Suite 204, 100 Main Street, Whitehorse, Yukon, (403) 668-3424. Similar services may be available from other experienced energy consultants.

Further Information:

Further information on this project and a copy of the interim report are available from:

- ENEROPTIONS
  Energy Branch
  Department of Mines and Small Business
  Government of Yukon
  P.O. Box 2703
  Whitehorse, Yukon
  Y1A 2C6
  (403) 667-5382

Information is also available from the project manager for the apartment retrofits:

- Don Cosetto
  (re: ENEROPTIONS)
  Yukon Housing Corporation
  205-303 Jarvis Street
  Whitehorse, Yukon
  Y1A 3H3
  (403) 667-5755

Skookum Jim Friendship Centre

Technology:
- Training
- Building retrofit and renovation

Demonstration Project Manager:
Stan Boychuk
Skookum Jim Friendship Centre
3159-3rd Avenue
Whitehorse, Yukon
Y1A 1G1

Location:
Whitehorse, Yukon

Annual Savings:
- almost 75% per unit volume for the Centre
- average 40% for building retrofits

Payback Period: Not applicable

Applicable to:
- Native communities
- Remote communities

Description:
The combination of planning foresight and energy-efficient building technologies has paid off handsomely for Whitehorse's Skookum Jim Friendship Centre and eight Yukon native communities. By 1983 the twenty-two year old native centre was experiencing serious operational constraints due to extremely high energy costs and a general need to expand and upgrade its facilities. At the same time, similar concerns — high energy costs and a need for building upgrading — were being expressed throughout all of the Yukon's remote native communities. Consequently, the Skookum Jim Friendship Centre chose to address both its own immediate needs and those of other Yukon remote native communities in this one project.

The project was conducted in two phases. Phase I of the project stressed proper energy conservation construction techniques. This 8-month segment of the project consisted of both formal classroom training as well as practical "hands-on" experience — by actually retrofitting and renovating the Skookum Jim Friendship Centre.

In Phase II, the newly acquired energy conservation skills of the 10 carpenter trainees were put into practice in each of the 8 participating communities. This Phase of the project served to both demonstrate building retrofit techniques in each community and to provide on-site project management experience for each of the trainees.

Installing fibreglass insulation during a total retrofit in Mayo, Yukon

As a result of the project:

- The Skookum Jim Friendship Centre now has a completely renovated, energy-efficient facility which is twice as large as the original facility but costs only half as much to heat;
- More than 40 building energy retrofits and 2 new energy-efficient homes have been completed within the participating communities; and
- Each of the 8 participating native communities now has a trained Band member to assist them in future energy-efficiency improvements to their community buildings.

Benefits:

The project has resulted in substantial direct energy savings and is considered to be an excellent model for energy retrofit training programs in other remote native communities. The specific benefits are:

- The new Centre offers an improved facility for its continuing programs and services. The size of the building has been increased from 850 m³ (30,000 ft³) to 1,713 m³ (60,500 ft³), yet annual heating costs for the new larger facility are about 50% less than for the original smaller facility;
- Average annual energy savings of about 40% are expected in each of the more than 40 homes retrofitted within the participating communities;
- The 10 carpenter trainees have received extensive practical experience in energy-efficient construction techniques which will be directly applicable to construction activity within their respective communities; and
- The formal classroom training has resulted in the development of curriculum material which will be useful for related future projects.

Performance:

The retrofit training program proceeded as expected and has met its major objectives — improved Centre facilities, participant skills training and improved Band housing.

At the conclusion of the training program, each participant successfully completed a certification exam.

The previous heating costs for the old Centre were about $10,600 annually. The renovated Centre, with double the volume, had an annual heating bill of about $5,000 for 1984. As Phase II of the project was just completed in early 1985, performance data for the Band housing retrofits are not yet available.

Technical Details:

Phase I of the retrofit training program commenced in June 1983. The ten carpenter trainees were selected by the Skookum Jim Friendship Centre in conjunction with local Band councils.

The formal classroom portion of the training program was based on modified curriculum material, originally developed by the Advanced Education Branch of the Yukon Department of Education. The material covered all aspects of energy retrofit as well as low-energy building design and construction techniques.

Practical experience was gained under the supervision of a journeyman carpenter and a site foreman. The actual construction work required on the Centre involved both the retrofit of the existing facility and the addition of a second storey. Consequently, it afforded a practical demonstration of both energy retrofit and new, energy-efficient construction techniques.

Throughout Phase I, emphasis was placed on techniques which were most cost-effective and appropriate for remote communities. For example, in the retrofit of the existing facility:

- Disassembly techniques were demonstrated and the importance of salvaging as a method of reducing materials costs was emphasized;
- A Curtain Wall system was used to retrofit the main floor walls of the original building to an insulation level of RSI 7.7 (R 44);
- The concrete basement walls were insulated on the exterior with RSI 1.8 (R 10) of styrofoam to the footings and double that amount for the top 61 cm (24 in);
- When examples of moisture damage were discovered in the old building, they were used to emphasize proper air and moisture management techniques.

Similarly, during the new construction phase:

- "Double stud-walls" were used on the second storey to gain additional space and allow for RSI 7.7 (R 44) insulation;
- Ten mil polyethylene was used for an air-vapour barrier due to its greater puncture resistance, and proper sealing techniques were demonstrated with particular emphasis given to sealing techniques around doors, windows, plumbing stacks and electrical penetrations;
- A lumber and plywood beam was used as an alternative to dimensional lumber; these can be fabricated in a remote community and are less expensive than long-span, wide-dimension lumber joists;
- Despite the availability of prefabricated trusses, site-built lumber-plywood roof trusses were used as they are the most practical option in remote communities; these featured "high heels" to accommodate RSI 10.6 (R 60) insulation levels all the way to the edge of the wall;
- New vestibules were built at either end of the building to provide buffer zones as people entered during cold weather and to accommodate new stairwells from the basement to the second storey. The vestibules were balloon-framed and insulated to RSI 3.5 (R 20);
- Preserved wood foundations were used for the construction of the new vestibules in order to give the crew experience with a method of basement construction which is less expensive and more appropriate in remote communities. They were insulated to RSI 3.5 (R 20) below grade;
- A cathedral ceiling was constructed on the north vestibule using a modified plywood and lumber beam system which allowed for RSI 10.6 (R 60) insulation;
- Window openings were relocated and strengthened to accommodate the new triple-glazed windows;

- Tyvek was used in place of conventional exterior sheathing;
- The HVAC system consists of two air-to-air heat exchangers interconnected to achieve variable volume air recycling with electric resistance duct heaters to provide zoned temperature control.

Phase II of the project commenced in May of 1984 and was completed on March 31,1985. This Phase involved 4 weeks of intensive retrofit activities in each of the 8 participating communities. Delivery of this project in each community was as follows:

- Several weeks prior to the commencement of activities, the community trainee and one of the course instructors conducted a detailed assessment of all Band-owned houses and prepared a retrofit/renovation plan for each house;
- Based on the individual house assessments, the trainee and instructor prepared a proposed work plan for review and approval by the Band Council. In order to maximize local training and technology transfer objectives, several different levels and types of retrofits were included in each work plan. The actual number of homes to be retrofitted in the 4 week period was determined by the level of retrofits and by the number of local carpenters (in addition to the 10 project trainees and 2 instructors) that the Band Council was able and willing to dedicate to the project. Consequently, the actual number of homes retrofitted in each 4 week period varied from a low of 3 major retrofits to as many as 18 major, medium and low level retrofits;
- In each case, the local trainee assumed the role of project manager and was responsible for all site requirements (e.g., materials procurement, timetable, etc.);
- Approximately 2-3 weeks after the initial site visit, the crew of 10 trainees, 2 instructors and the local carpenters chosen for the task began the intensive 4 week period of work.

This procedure was repeated in each of the 8 communities and in each case the roles of project manager, site foreman, crew boss, etc. were rotated among the trainees. At the completion of the project, each of the trainees returned to their community, where, in many cases, they assumed the role of local Housing Coordinator.

Economic Analysis:

The major objective of this project was technology transfer to the 8 participating remote native communities through skills training and demonstration. Consequently, a substantial portion of both direct and indirect project costs was incurred in meeting this primary objective. The consensus among all parties involved in this project is that this primary objective has been effectively met. Therefore, a conventional economic analysis of only the project's actual retrofit activities would be inappropriate and would seriously undervalue the project's achievements.

Nonetheless, consideration of the project's total costs versus actual and projected energy savings shows very favourable economic returns. Specifically:

- The total cost of Phase I, including the development and presentation of the formal training sessions and supportive audio-visual and written materials as well as all materials and labour for the renovation of the Skookum Jim Friendship Centre, was $355,000. This cost is approximately equal to $710/m² ($66/ft²) for the new facility and compares with a prevailing northern construction cost of about $775/m² ($72/ft²) for a similar facility, constructed to conventional energy standards under normal contracting arrangements. Hence, despite the inclusion of an extensive training component, the new Centre was actually built below market cost. This cost savings resulted from:
  - — the Centre assuming the role of general contractor
  - — extensive use of salvaged materials
  - — labour rates paid to the trainees which were below market rates normally charged by general contractors.
- The total cost of Phase II was $258,000. Approximately 40 native buildings received retrofit measures and 2 new energy-efficient buildings were constructed. Energy savings were from 20 to 60%, with an average savings of 40%.

Availability:

The building materials used are readily available in most of Canada; although, in remote communities, availability of some materials may be restricted and hence alternative techniques may be necessary.

ARCTECH Community Energy Research Associates, a local Whitehorse energy conservation firm, assisted in the building design, presented the formal classroom training and assisted in the delivery of the community retrofits.

Further Information:

Further information and a copy of the final project report are available from:

- ENEROPTIONS
  Energy Branch
  Department of Mines and Small Business
  Government of Yukon
  P.O. Box 2703
  Whitehorse, Yukon
  Y1A 2C6
  (403) 667-5382

Audio-visual and curriculum material developed for the program are available from:

- Stan Boychuk
  (re: ENEROPTIONS)
  Skookum Jim Friendship Centre
  3159-3rd Avenue
  Whitehorse, Yukon
  Y1A 1G1
  (403) 668-4465

ENEROPTIONS CASE STUDY

NWT 12

Lac La Martre School Waste Heat Recovery

Technology:
Waste heat recovery from diesel generator

Demonstration Project Manager:
Mr. Dana Ferguson
Ferguson, Simek, Clark Ltd.
Box 1777
Yellowknife, N.W.T.
X1A 2P4

Location: Lac La Martre, N.W.T.

Annual Savings: $26,485
99% of oil consumption without heat recovery

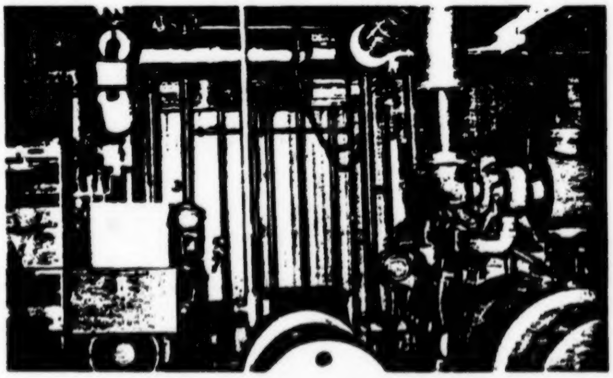
Payback Period: 9 years

Applicable to:
Remote communities served by diesel power plants and having suitable space heating/domestic hot water loads.

Description:

A school in a remote N.W.T. community is heated by waste heat from a diesel generator. In the summer of 1981, a new community school of 1,800 square metres (19,380 sq. ft.) was built at Lac La Martre, 164 km. northwest of Yellowknife. The new school incorporated many new energy conservation features and was situated 100 metres from an existing Northern Canada Power Commission (NCPC) diesel power plant.

A system to recover waste heat from the jacket water and exhaust was designed and installed on the existing NCPC diesel power plant. The waste heat is now transferred to the adjacent school where it provides space and domestic water heating. This process effectively reduces the school's boiler operation to a minimum, without affecting the NCPC plant production.



Benefits:

A number of benefits are realized through recovering waste heat from the generator's jacket water and exhaust. These benefits include:

- The waste heat recovery system provides almost 100% of the school's space and water heating requirements.
- The exhaust recovery unit cuts noise transfer from the generator so that it is now almost inaudible when standing outside the NCPC enclosure.

Performance:

The design and installation of the heat recovery system proceeded as expected, without encountering major problems. The system's performance has slightly exceeded expectations and no maintenance problems have been encountered.

After one complete heating season (1982-83), the project is considered to be very successful by all parties involved — the community, NCPC, maintenance staff, and the Government of the Northwest Territories (GNWT).

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

It was found that the NCPC load and the school's heat requirements are in phase. The actual quantity of heat supply and demand are well matched, particularly in the crucial winter months. It was determined that for each 1 kW of generator electrical output, 1.32 kW of recoverable waste heat is produced.

NCPC reported no operational or maintenance problems with the heat recovery system. NCPC indicated that the generators' engine temperature was being maintained at a satisfactory 80° C (176° F) with flue gas temperature fairly steady at 210° C (410° F).

The community and GNWT are similarly pleased with the resulting savings in the school's fuel oil requirements. Actual consumption for the first year of operation was 370 litres.

This represents an annual fuel oil savings of about 49,800 litres from the projected consumption — a 99% savings.

Problems encountered in the second year of operation have been attributed to a lack of trained and motivated staff to do routine maintenance on the distribution system.

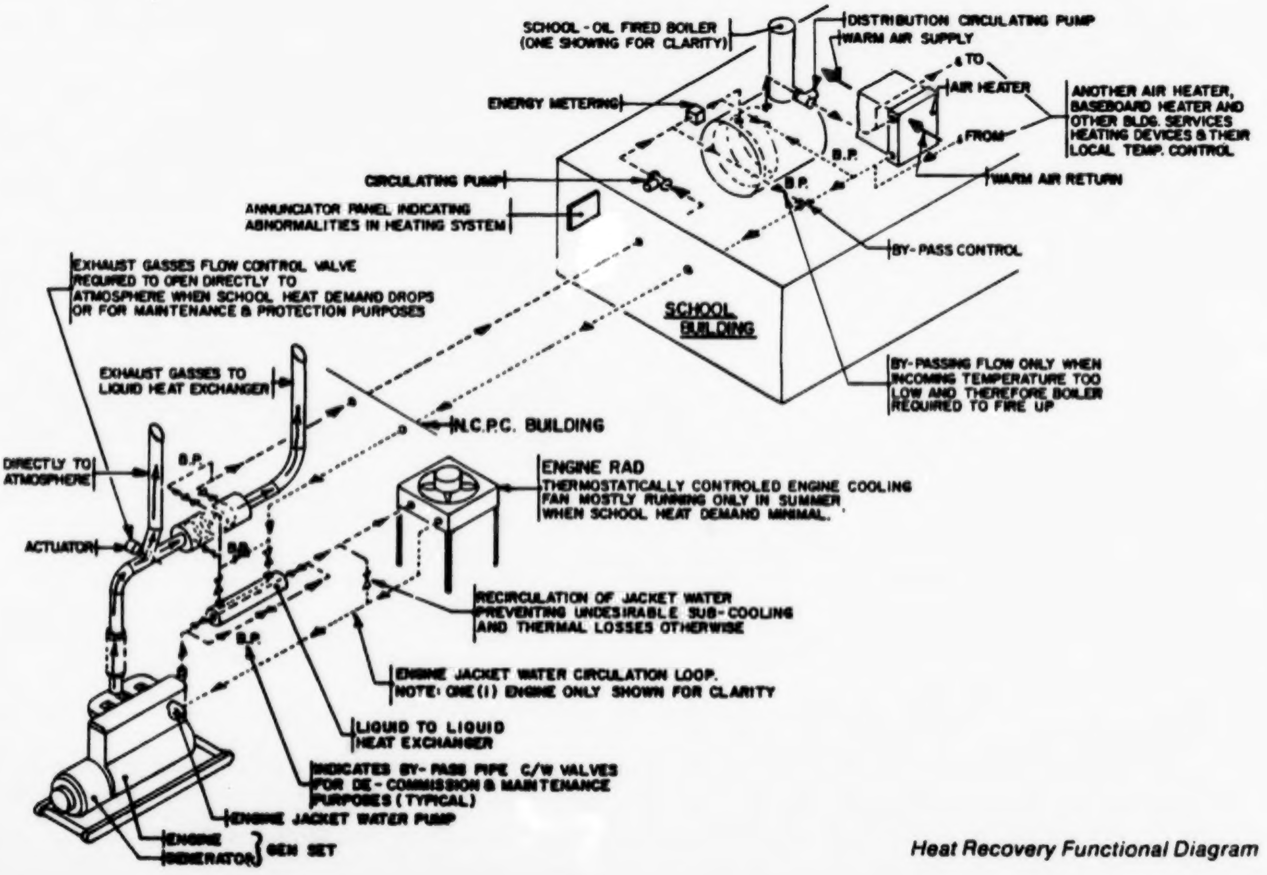
Technical Details:

Three NCPC generators provide the total community power supply. Two of these units — a Caterpillar 3406 with a 281.25 kVa generator and a Caterpillar D-342 with a "Kato" 187.5 kVa generator — are connected to the heat recovery system. Below is a functional diagram of the installed system.

Due to the size of the projected heating load and the plant's output capacity, waste heat is recovered from both the generators' jacket water and exhaust flue gas via installed heat exchangers shown in the functional diagram. When the generator output exceeds the school's load requirement, jacket water heat is rejected via the remote engine radiator which is equipped with a thermostatically controlled cooling fan. A control valve directs the flue gas to the atmosphere via a conventional muffler when exhaust heat recovery is not required.

The heating system is filled with a pre-mixed solution of 50% propylene glycol and 50% water. The diesel waste heat is transferred to the school using 63 mm schedule 40 welded steel pipes. The pipes are insulated with 38 mm thick polyethylene insulation wrapped in a 45 mil polythylene black jacket.

The insulated pipe was installed at a depth of .6 m. Soils are not thaw-stable in permafrost, consequently, timber sleepers were used extending beyond the influence of the thaw bulb created by the pipes.


SCHOOL - OIL FIRED BOILER (ONE SHOWING FOR CLARITY)
DISTRIBUTION CIRCULATING PUMP
WARM AIR SUPPLY
TO
AIR HEATER
ANOTHER AIR HEATER, BASEBOARD HEATER AND OTHER BLDG. SERVICES HEATING DEVICES & THEIR LOCAL TEMP. CONTROL
FROM
ENERGY METERING
B.P.
CIRCULATING PUMP
B.P.
WARM AIR RETURN
ANNUNCIATOR PANEL INDICATING ABNORMALITIES IN HEATING SYSTEM
BY-PASS CONTROL
EXHAUST GASSES FLOW CONTROL VALVE REQUIRED TO OPEN DIRECTLY TO ATMOSPHERE WHEN SCHOOL HEAT DEMAND DROPS OR FOR MAINTENANCE & PROTECTION PURPOSES
SCHOOL BUILDING
EXHAUST GASSES TO LIQUID HEAT EXCHANGER
BY-PASSING FLOW ONLY WHEN INCOMING TEMPERATURE TOO LOW AND THEREFORE BOILER REQUIRED TO FIRE UP
N.C.P.C. BUILDING
DIRECTLY TO ATMOSPHERE
B.P.
ENGINE RAD
THERMOSTATICALLY CONTROLED ENGINE COOLING FAN MOSTLY RUNNING ONLY IN SUMMER WHEN SCHOOL HEAT DEMAND MINIMAL.
ACTUATOR
B.P.
RECIRCULATION OF JACKET WATER PREVENTING UNDESIRABLE SUB-COOLING AND THERMAL LOSSES OTHERWISE
B.P.
ENGINE JACKET WATER CIRCULATION LOOP. NOTE: ONE (1) ENGINE ONLY SHOWN FOR CLARITY
LIQUID TO LIQUID HEAT EXCHANGER
INDICATES BY-PASS PIPE C/W VALVES FOR DE-COMMISSION & MAINTENANCE PURPOSES (TYPICAL)
ENGINE JACKET WATER PUMP
ENGINE
GENERATOR
GEN SET

Heat Recovery Functional Diagram

The school heating system was designed to be completely self contained. It consists of: two oil-fired boilers, each with a rated output of 159 kW; perimeter baseboard heating; and two ventilation systems supplying tempered outside air as required. The domestic hot water is also supplied by the diesel waste heat, with cold water being circulated through tankless heat exchangers and stored in insulated tanks. An electric heater was installed as emergency backup only.

The school heating system was designed to operate at 62° C (144° F) which would normally be supplied from the NCPC recovery lines. The hot water passes in series from the NCPC recovery lines through the boilers, which will bring the water up to 62° C (144° F), if necessary. An operating aquastat controls the boilers when NCPC cannot supply enough heat.

If the NCPC water supply temperature falls below 49° C (120° F), the heat recovery line aquastat modulates a 3-way valve to recirculate the water back to NCPC rather than through the school heating system. A thermostat installed on the heating water supply line will initiate an alarm if the temperature drops below 43° C (109° F).

Separate circulating pumps for the school heating system and for transferring the hot water between the school and NCPC building are both located in the school boiler room.

Economic Analysis:

1. **Capital and Installation Costs:** $239,000

2. **Cost of Heating School:**	**Without Heat Recovery** (estimated)		**With Heat Recovery** (actual)	
• Fuel oil (@ $0.58/L)	50, 150 L =	$29,087	370 L =	$ 215
• Boiler electrical and oil transfer pumps (@ $0.573/kWh)	745 kWh =	427	6 kWh =	3
• Recirculating pump (@ $0.573/kWh)	none		4,906 kWh =	2,811
		$29,514		$3,029

Net Savings = $26,485

3. **Simple Payback Period:** 9 years

Availability:

Ferguson, Simek, Clark Ltd. of Yellowknife, N.W.T. designed and supervised installation of the heating system.

NCPC personnel carried out all modifications to the power plant equipment. Similar consulting services and equipment are generally available across Canada.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Energy Conservation Division
  Department of Public Works and Highways
  YK Centre, 5th Floor
  Government of the Northwest Territories
  Yellowknife, N.W.T.
  X1A 2L9
  (403) 873-7203

Information on this demonstration project is also available from the consultant:

- Ferguson, Simek, Clark Ltd.
  (re: ENEROPTIONS)
  Box 1777
  Yellowknife, N.W.T.
  X1A 2P4
  (403) 920-2882

ENEROPTIONS CASE STUDY

NWT 17

Super Energy Efficient Arctic Row Housing

BOREALIS CO-OPERATIVE — YELLOWKNIFE, N.W.T.

Technology:
New building energy efficiency

Demonstration Project Manager:
President
Borealis Co-operative Ltd.
Box 2039
Yellowknife, N.W.T.
X1A 2P5

Location:
Yellowknife, N.W.T.

Annual Savings: $133,250
75% compared with conventional construction standards

Payback Period: 3.7 years

Applicable To: Residential sector

Description:

The first multifamily dwellings in Canada to meet R-2000 energy efficiency standards are in Yellowknife, N.W.T. The Borealis Housing Co-operative Ltd. consists of 50 new town houses grouped into 9 blocks, ranging from duplexes to eight-plexes. The construction style is row housing on a common crawl space.

The units were constructed in 1983 using the latest recommended R-2000 energy conservation features and commercial products. These included southern orientation, increased insulation levels, sealed air-vapour barriers, poly electrical boxes, air-to-air heat exchangers, downsized propane furnaces in an enclosed furnace room, triple-glazed windows and an insulated crawl space on bedrock.

It takes a lot of insulation to achieve energy efficiency. These houses in the Borealis project need all they can get to protect them from frigid northern winters.

Benefits:

- Calculated annual fuel *savings* are approximately 75% of the consumption of units constructed to conventional energy efficiency standards.
- The project generated useful design alternatives for the treatment of the crawl space floor when situated on exposed bedrock.
- Incorporation of the energy efficiency features resulted in local tradesmen learning new skills and upgrading their employability.
- The project has clearly demonstrated that typical northern row housing can be adapted to incorporate state-of-the-art energy conservation techniques and can produce dramatic but cost-effective savings. The Hillside Co-operative in Frobisher Bay has adopted the same approaches.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Performance:

Construction of the project was completed on time and within budget. Occupancy took place in October, 1983. The total budget for 50 units was $5.2 million or $104,000 average per unit.

Although complete monitoring data is not yet available, actual fuel consumption data — for a 3 month winter period — compiled for one block of three units, indicate an annual savings of about $8,000 or 75% of the estimated heating costs for the same block if constructed to conventional standards. The simple payback is 3.7 years.

The units have experienced three significant problems to date.

- there is an unequal distribution of heat between upper and lower floors. The lower floors are cool while upper floors are comfortable. In part, poor air circulation—combined with infiltration from the crawl space—is felt to be the cause.
- the air-to-air heat exchangers have developed ice build-up during severe weather. Retrofit of vanEE "Frost Busters" should provide a solution to this northern problem.
- frost build-up is occurring in the attics.

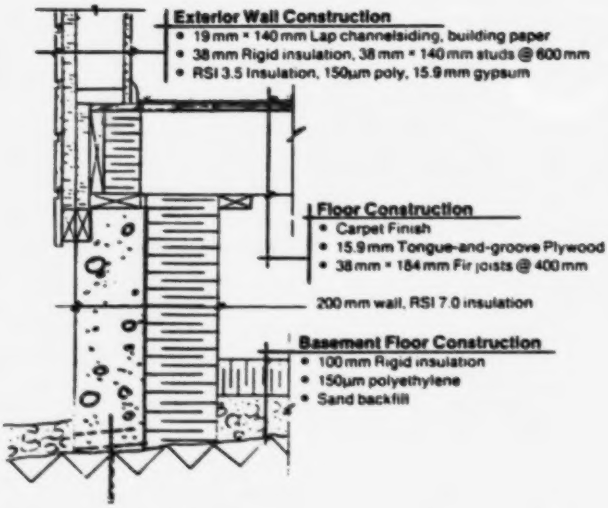
The installation of a return air duct on the lower floor is expected to resolve the first problem. Two speed circulating fans are also recommended for future applications. The Saskatchewan Research Council is currently investigating both of the remaining problems and a report suggesting remedial measures will soon be available.

Technical Details:

Each unit consists of: a living room on the lowest level; a kitchen, dining room, ½ bath, laundry and storage rooms on the main level, and; bedrooms and a bathroom on the upper level(s). Floor area is: 112 m² (1,200 ft ²) in the two-bedroom units; 128 m² (1,380 ft ²) in the three-bedroom units and; 153 m² (1,650 ft ²) in the four-bedroom units.

The design and construction of the units particularly emphasized six energy efficiency features:

- Orientation - The Borealis Co-op site slopes to the south and consists of exposed bedrock. To maximize solar gain and minimize exterior area, the units are grouped into 9 blocks running on an east to west axis.
- Controlled Air Leakage - The sealing of the air-vapour barrier was carefully addressed and inspected. Particular attention was devoted to such areas as; the junction of the foundation and the framing; electrical fixtures; plumbing vents; and chimneys. Infiltration tests were conducted by NORSASK of Saskatoon; 92% of the units met or exceeded the allowable air leakage standard of 1.5 air changes per hour at 50 pascals.
- Levels of Insulation — The units were insulated to RSI 10.5 (R 60) in the roof, RSI 6.0 (R 34) in the walls and RSI 7.0 (R 40) in the basement.
- Heat Exchangers - To maintain air quality, a vanEE heat exchanger was installed in each unit to recover heat from the stale exhausted air. Fresh air is ducted to the return air plenum where it can be heated prior to distribution. To control humidity levels, the heat exchanger is connected to a humidistat which activates the unit at a predetermined humidity level.
- Windows - Triple-glazed windows were used.


Exterior Wall Construction
• 19 mm × 140 mm Lap channelsiding, building paper
• 38 mm Rigid insulation, 38 mm × 140 mm studs @ 600 mm
• RSI 3.5 Insulation, 150μm poly, 15.9 mm gypsum
Floor Construction
• Carpet Finish
• 15.9 mm Tongue-and-groove Plywood
• 38 mm × 184 mm Fir joists @ 400 mm
200 mm wall, RSI 7.0 insulation
Basement Floor Construction
• 100 mm Rigid insulation
• 150μm polyethylene
• Sand backfill

Basement/Exterior Wall Section

- Heating System — Forced air, 90,000 Btu propane furnaces were downsized to provide a 40,000 Btu output. The furnaces are also equipped with electronic ignition, motorized flue dampers and night setback thermostats. Propane is also used for heating domestic hot water and for the operation of dryers and stoves.

Economic Analysis:

1. **Capital and Installation Costs for Energy Efficiency Features**
   (incremental costs)

Total for 50 units:	$502,343
Average cost/unit:	$ 10,047

The energy efficiency features appear to represent just under 10% of the total building cost.

2. **Annual Savings**

Estimated fuel cost/unit (without energy upgrading)	$ 3,560
Actual fuel cost/unit (with energy upgrading)	$ -895
Net Annual Saving	$ 2,665

3. **Simple Payback Period:** 3.7 years

Availability:

The Borealis Co-op was designed by Larrie Taylor, Architect Ltd. of Edmonton, Alberta and constructed by PCL Ltd., a local Yellowknife contractor.

All products and services employed in this project are available in major centres throughout Canada.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Energy Conservation Division
  Department of Public Works and Highways
  YK Centre, 5th Floor
  Government of the Northwest Territories
  Yellowknife, N.W.T.
  X1A 2L9
  (403) 873-7203

Further information on this demonstration project is also available from:

- Borealis Co-operative Ltd.
  (re: ENEROPTIONS)
  Box 2039
  Yellowknife, N.W.T.
  XIA 2P5
  (403) 920-2467
- Larrie Taylor
  (re: ENEROPTIONS)
  Larrie Taylor, Architect Ltd.
  200-9959 Whyte Avenue
  Edmonton, Alberta
  T6E 1Z1
  (403) 432-1028

Snowshoe Inn Ltd. Waste Heat Recovery

Technology:
Waste heat recovery and distribution from diesel jacket water and exhaust

Demonstration Project Manager:
Mr. Dana Ferguson
Ferguson, Simek, Clark Ltd.
Box 1777
Yellowknife, N.W.T.
X1A 2P4

Location:
Fort Providence, N.W.T.

Annual Savings: $128,000
68% of conventional electricity and heating costs

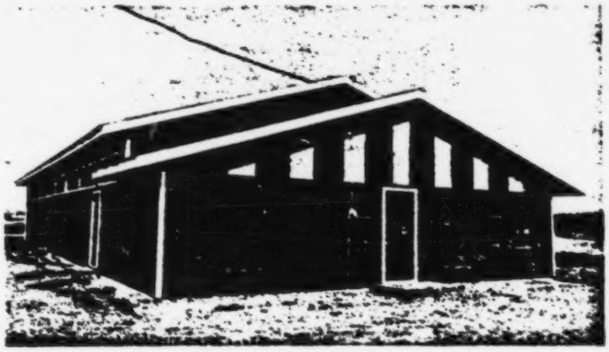
Payback Period: Under 2 years

Applicable to:
Remote communities served by diesel power plants and having suitable space heating/domestic hot water loads.

Description:

The Snowshoe Inn Ltd. is located in Fort Providence, N.W.T., a remote community situated 233 air kilometres (145 miles) southwest of Yellowknife, N.W.T.

In 1971, the owner began to plan for a major expansion of the Snowshoe Inn's facilities. In order to keep power and heating costs to a minimum, he installed his own diesel power system with heat recovery. Waste heat from both the diesel water jacket and exhaust is recovered and provides space heat and domestic hot water to the adjoining buildings.



Snowshoe Inn craft shop/restaurant complex

Benefits:

This project is providing very substantial economic benefits to the Snowshoe Inn. Based on an economic and engineering review of the system, it is estimated that the Snowshoe Inn is realizing an annual savings of approximately 65% on its total power, space heat and domestic hot water costs.

The project has also shown that the use of an underground steel culvert to distribute piping is a very practical idea for the North. Hot and cold water pipes, sewage pipes and even electrical cables can be run through the culvert. Because the culvert is 1 m (3.3 ft) in diameter, the piping is easily accessible and if warm air is blown through, no insulation is required on thaw-stable soils.

Finally, the project has demonstrated that underfloor heating is a practical approach to using low-grade waste heat for space heating purposes.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Performance:

When installed in 1973, cost savings were estimated to be $2,500/month. Actual savings slightly exceeded this projection and their value has increased substantially over the past 12 years due to both the rapid increase in fuel costs and the continued expansion and modification of the system.

The project has benefitted significantly from the owner's strong background in mechanical engineering. Over the last 12 years he has carried out numerous system modifications and improvements.

Three improvements were particularly important:

- the installation of a heated 1,000 mm galvanized steel culvert which serves as a utilidor;
- the replacement of the conventional polyethelene distribution piping with polybutylene pipe in order to overcome leakage problems that occured as a result of radial cracks which developed at the joints;
- the installation of underfloor heating in buildings.

Technical Details:

Three diesel generators provide the power, space heat and domestic hot water requirements of the Snowshoe Inn. They are: a GM 4-71 diesel with a 75 kW Tamper generator; a GM 6-71 diesel with a 100 kW Tamper generator; and a turbo charged GM 6-71 diesel with a 175 kW Brown Boveri generator.

Waste heat is recovered from both jacket water and exhaust gases. Details of the jacket water and exhaust heat recovery system are shown in Figure 1.

The heating system is an "open" system operating at a pressure of approximately 75 kPa (11 psi). This pressure is created by the static head of the 18,000 litre (3,960 gal) storage/surge tank, shown in Figure 1. A 200 litre (44 gal) header tank, located on top of the 18,000 litre storage tank, is connected to the cold water supply and maintains the system capacity.

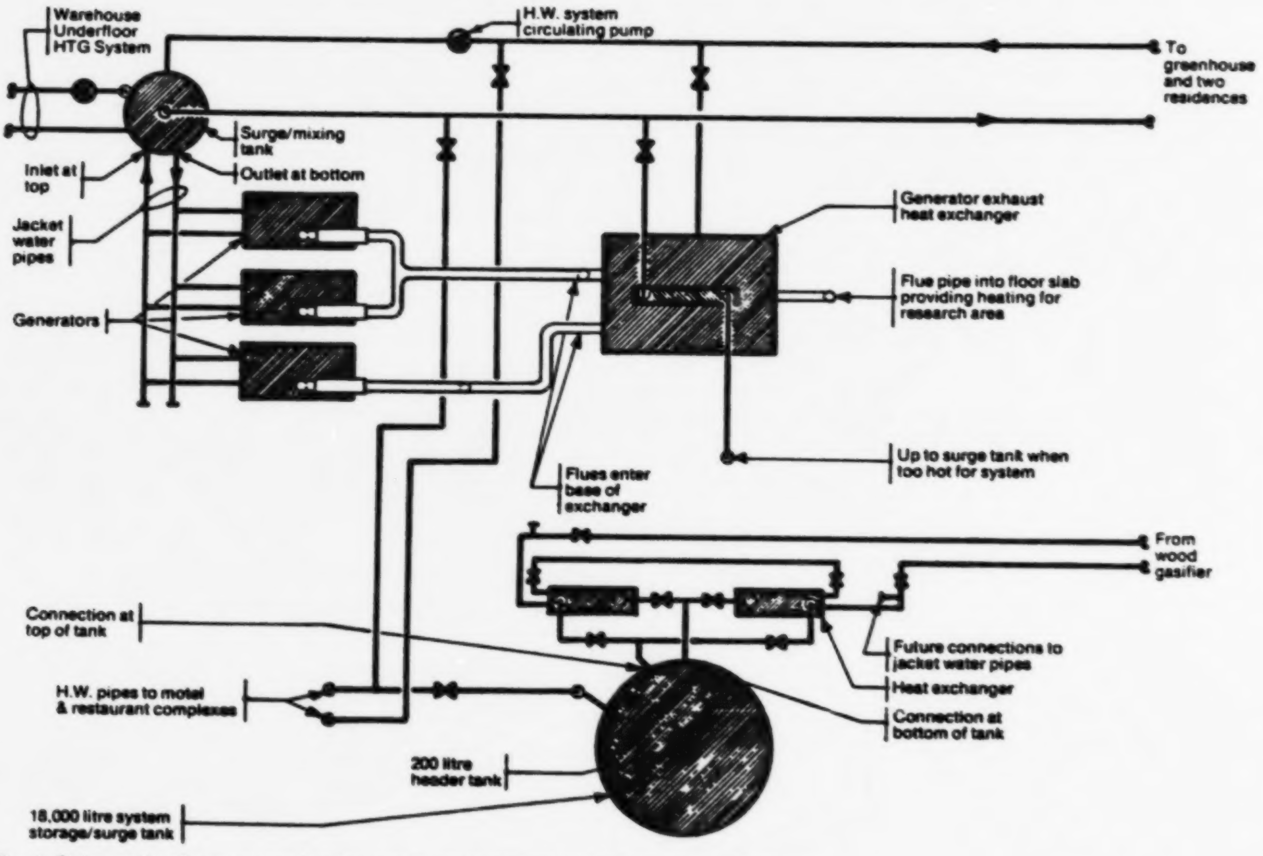

Warehouse Underfloor HTG System
H.W. system circulating pump
To greenhouse and two residences
Surge/mixing tank
Inlet at top
Outlet at bottom
Jacket water pipes
Generators
Generator exhaust heat exchanger
Flue pipe into floor slab providing heating for research area
Up to surge tank when too hot for system
Flues enter base of exchanger
From wood gasifier
Connection at top of tank
Future connections to jacket water pipes
Heat exchanger
H.W. pipes to motel & restaurant complexes
Connection at bottom of tank
200 litre header tank
18,000 litre system storage/surge tank

Fig. 1 Schematic of generators' jacket water and exhaust heat recovery systems

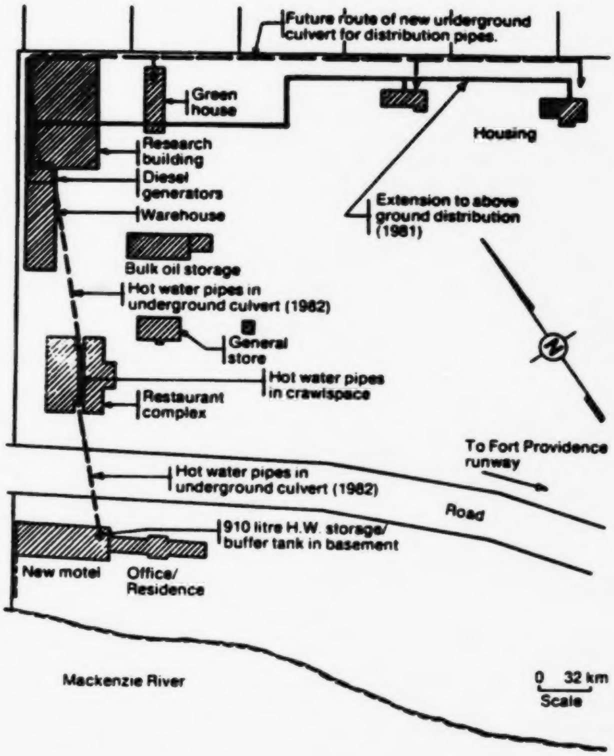
The distribution system is shown in Figure 2. In 1982, the previous wooden utilidor system was replaced by a 1 m (3.3 ft) diameter galvanized steel culvert. This steel culvert is used as an oversized utilidor and runs underground from the warehouse to the restaurant and new motel. As shown in Figure 2, a second section of underground culvert is planned as a replacement to the current above-ground extension to the distribution system.

The culvert contains the two hot water pipes carrying the diesel waste heat as well as a cold water pipe. Polybutylene pipe is now used instead of polyethelene pipe in order to avoid the problem of cracking. Excess warm air from the generator room is blown through the culvert. This maintains the air temperature inside the culvert well above freezing as well as keeping the pipes' heat loss to a minimum.

Hot water from the waste heat recovery system provides space heat to: a warehouse, a research building, a greenhouse, two residences and a motel and restaurant complex.

Although the heating system in each building has its own unique characteristics, most of the buildings are now provided with underfloor heating. For example, in the motel office and residence, 15 mm polybutylene pipes were laid on the wooden floor and clamped down. To keep the pipes flat, chicken wire was also laid across the floor and tacked down. A 32 mm thick layer of lightweight concrete was then laid on top of the pipes, and followed by the floor finish. Electric baseboard heaters have also been installed to provide temperature "fine tuning", if required.

Domestic hot water is also provided by the heat recovery system. Electric water heaters are used to increase the water temperature, if required.



Future route of new underground culvert for distribution pipes.
Green house
Research building
Diesel generators
Warehouse
Housing
Extension to above ground distribution (1981)
Bulk oil storage
Hot water pipes in underground culvert (1982)
General store
Hot water pipes in crawlspace
Restaurant complex
To Fort Providence runway
Hot water pipes in underground culvert (1982)
Road
910 litre H.W. storage/ buffer tank in basement
New motel
Office/ Residence
Mackenzie River
0 32 km
Scale

Fig. 2 Snowshoe Inn site upgraded hot water distribution system

Economic Analysis:

The capital cost of the original system installed in 1973 was $50,000. This included two diesel generators, the heat recovery and overground distribution system and labour (except for that of the owner). Annual savings attributed to heat recovery in 1973 were approximately $30,000. The simple payback on the original system was therefore less than 2 years.

In 1982, Ferguson, Simek, Clark Ltd. documented the system and undertook an updated economic analysis.

Actual electricity consumption records from the Snowshoe Inn's diesel power plant were totalled for the 12 month period May 1981 to April 1982. These figures were then used to determine what the Inn's electricity costs would have been if power had been purchased from the local utility — Alberta Power Ltd. Similarly, records of actual space heating requirements were used to estimate the Inn's hypothetical heating costs if, instead of using waste heat, fuel oil had been purchased and burned in a conventional heating system.

These hypothetical costs were then compared to the Inn's actual total power and space heating costs incurred with the diesel generator/heat recovery system. The results are presented below:

Estimated conventional electricity cost:	$168,000
Estimated conventional space heating cost: 74,074 L @ $0.27	20,000
Estimated Total Conventional Cost:	$188,000
Actual diesel fuel cost: 218,000 L @ $0.27	$ 58,860
Actual engine lubricant oil cost: 818 L @ $1.00	818
Actual Total Cost:	($ 59,678)
Annual Energy Savings: (Estimate)	$128,322

Availability:

The owner designed and supervised the installation of the entire system himself.

The technology is widely available through engineering consultants, contractors and suppliers in major centres throughout Canada.

Further Information:

Further information and a copy of the 1982 report is available from:

- ENEROPTIONS
  Energy Conservation Division
  Department of Public Works and Highways
  Government of the Northwest Territories
  YK Centre, 5th Floor
  Yellowknife, N.W.T.
  X1A 2L9
  (403) 837-7203

The 1982 report was prepared by:

- Mr. Dana Ferguson
  (re: ENEROPTIONS)
  Ferguson, Simek, Clark Ltd.
  Box 1777
  Yellowknife, N.W.T.
  XIA 2P4
  (403) 920-2882

ENEROPTIONS CASE STUDY NWT 21

Wood Heating of Fort Smith Water Supply

Technology:
Large-scale, direct combustion of wood chips

Demonstration Project Manager:
Jack Dueck
Apsco Engineering Ltd.
P.O. Box 270
Cremona, Alberta
T0M 0R0

Location:
Fort Smith, N.W.T.

Annual Savings: $44,471
100% of fuel oil previously used

Payback Period: 4.6 years

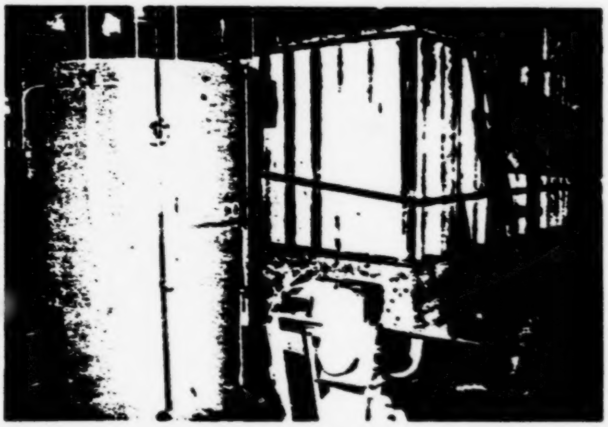
Applicable to:

- a wide range of institutional, municipal and commercial space and water heating applications
- of particular interest to northern communities requiring heated water supply.

Description:

Fort Smith, N.W.T. is saving over $44,000/year and creating local employment by heating its water supply with wood. Fort Smith, located approximately 300 km (185 miles) south of Yellowknife, must heat its water supply during much of the year. As in many communities in the Northwest Territories, the town's water supply was previously heated by conventional oil-fired boilers. However, escalating fuel oil prices dramatically increased the system's operating costs and prompted the search for a less expensive alternative.

The town's water supply is now heated by means of a 4.0 MBtu/hr Apsco Model WW1000 wood-fired hot water boiler unit. The boiler is fuelled by wood chips, processed on-site from locally purchased cordwood.



The wood-fired boiler is seen to the left and the wood-chip storage bunker is to the right. The inclined auger is seen in the foreground.

Benefits:

- In its first year of operation, the project resulted in the displacement of approximately 160,000 litres (35,195 gallons) of No. 2 fuel oil.
- Once start-up problems, related to chip bridging in the storage bin, are overcome, it is expected that the project will result in the total displacement of approximately 200,000 litres (45,000 gals) of No. 2 fuel oil by approximately 400 cords of local wood.
- The new wood boiler has a larger capacity than the oil boilers. This enables the water supply to be maintained at a higher and more optimal temperature (4.4° C) for more effective water treatment than previously (2° C).
- Three permanent part-time jobs have been created in connection with the harvesting, delivery and chipping of local cordwood. Funds spent on fuel now stay in the community.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Performance:

The design and installation of the system proceeded as expected and no problems were encountered. The boiler has performed at, or above, expectations since installation. A minor start-up problem was encountered with the wood chipper but was quickly identified and eventually remedied. There has been a continuing problem, however, with the wood-chip handling system. Each problem is outlined below.

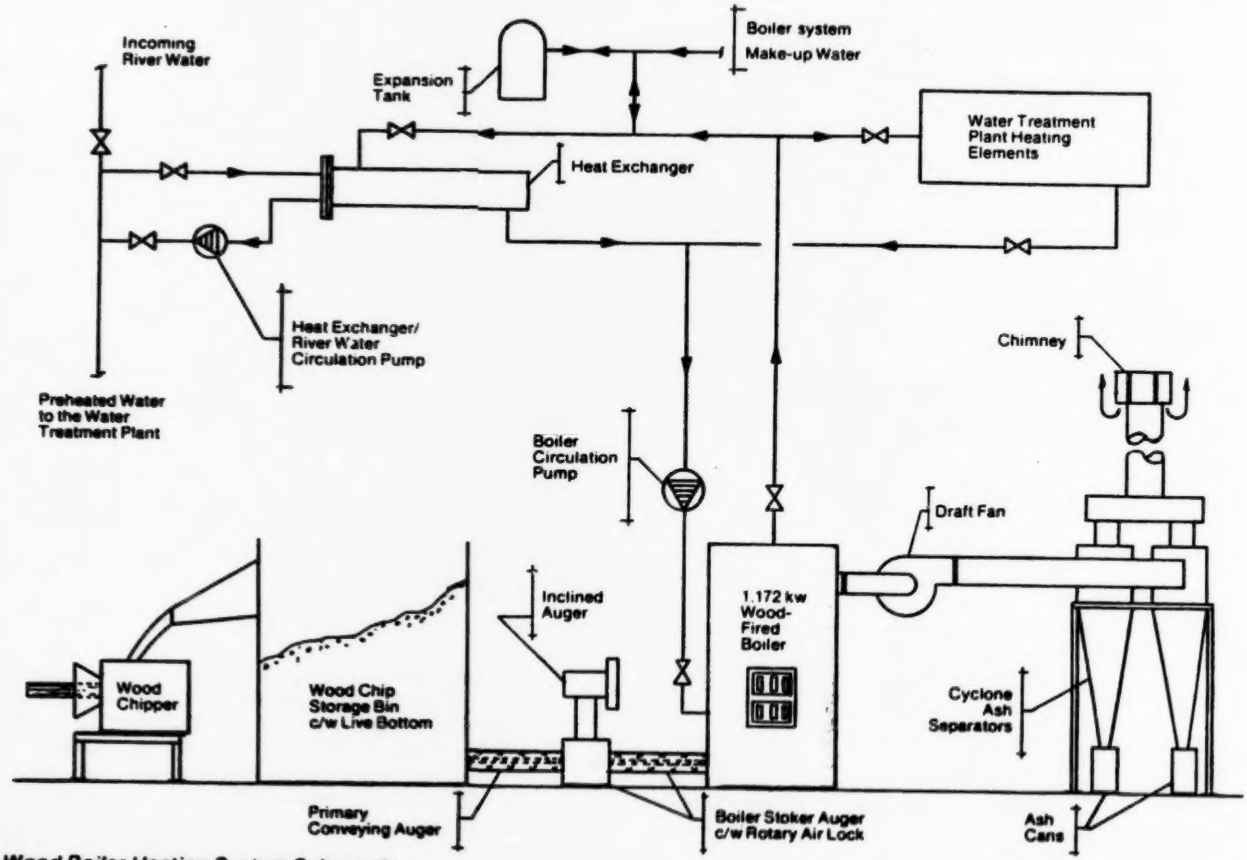
- Wood chipper — The attachment blades originally provided by the supplier were shorter than those specified by the design engineer. As a result, the chips were not being adequately thrown from the chipper unit to the conveyor belt. The problem was quickly identified and proper replacement blades were provided by the supplier. However, due to the inexperience of the on-site personnel, the replacement blades were not installed for several months. Once the replacement blades were installed, the chipper unit performed well.
- Wood-chip handling system — A continuing chip bridging problem exists with the hydraulic live bottom in the storage bin. This problem has lowered the system's availability to about 80% and is currently under investigation but is felt to be correctable.

Technical Details:

The schematic diagram shows the new wood boiler system. All facilities, including the chipper and storage bunker, are located indoors in an insulated steel building.

Wood fuel is chipped to allow automatic feeding of the boiler. The wood-chip storage bin has a live bottom which allows the primary auger at the base of the storage bin to meter the flow as required. The primary auger has a variable speed drive enabling the boiler feed rate to be adjusted according to heating requirements and/or fuel moisture content. A rotary air lock provides a separation between fuel and the firebox.

The Apsco Model wood-fired boiler is a three-pass, vertical fire tube boiler with a design thermal efficiency of 75%. The design allows the hot gases from the firebox to travel vertically through the boiler in three passes before exiting. Primary combustion air is provided from beneath the boiler. The gases produced during primary combustion are burned above the wood chips when mixed with secondary air. Both the fuel feeding rate and the air supply are adjusted to achieve an efficient fuel/air mixture under various operating conditions.


Incoming River Water
Expansion Tank
Boiler system Make-up Water
Water Treatment Plant Heating Elements
Heat Exchanger
Heat Exchanger/ River Water Circulation Pump
Preheated Water to the Water Treatment Plant
Chimney
Boiler Circulation Pump
Draft Fan
Inclined Auger
1.172 kw Wood-Fired Boiler
Wood Chipper
Wood Chip Storage Bin c/w Live Bottom
Cyclone Ash Separators
Primary Conveying Auger
Boiler Stoker Auger c/w Rotary Air Lock
Ash Cans

Wood Boiler Heating System Schematic

The boiler is supplied with a complete set of controls to maintain a preset boiler supply water temperature. The water side of the boiler supplies two separate loops. The primary loop feeds the new heat exchanger which heats part of the incoming river water before it enters the water treatment plant. The portion of the river water (at .5° C) that passes through the heat exchanger has its temperature raised to a point that, when mixed with the remaining portion, results in a water temperature of approximately 4.4° C (40° F).

The second loop from the boiler heats the water treatment plant. The existing oil-fired boilers now serve as backup.

As a result of the extremely high boiler hearth temperatures, almost all of the hydrocarbons are consumed and only fly ash remains. The fly ash is separated from the exhaust emissions with high efficiency cyclones.

Economic Analysis:

Capital and Installation Costs: $206,874

Avoided Cost of Fuel Oil (195,138 L @ $0.353):		$ 68,835
Annual Operating Cost for Wood Boiler		
• Cost of wood supply:		
- Harvesting and delivery (392 cords @ $37.50)	$14,700	
- Labour for wood chipping (336 hrs @ $8)	$ 2,688 (1)	
• Incremental maintenance cost:	$ 469 (1)	
• Incremental electricity cost:	$ 6,507 (2)	
Total	$24.364 (3)	($ 24,364)
Net Annual Savings		$ 44,471

Simple Payback Period: 4.6 years.

Notes:

1. Incremental labour costs for wood chipping and regular maintenance are site-specific and are dependent on current labour loading. In many locations, these tasks may be handled by existing staff.
2. Incremental electricity costs are primarily for operation of the electric chipper; in Fort Smith the levy of an energy demand charge of $4,771 makes the operation of an electric chipper far more expensive than the comparable operating cost of a gas-powered chipper. Additional annual operating cost savings of approximately $4,000 are possible through the use of a gas-powered chipper.
3. In those locations where a gas-powered chipper is used and existing staff are able to perform wood chipping and regular maintenance duties, annual operating costs for a comparable wood system may be as low as $21,000. This would result in a simple payback of 4.3 years.

Availability:

The system was designed and installed by Apsco Engineering Ltd. of Cremona, Alberta.

The technology is available through contractors, suppliers and engineering consultants in major centres throughout Canada.

Further Information:

Further information and a copy of the final report are available from:

- ENEROPTIONS
  Energy Conservation Division
  Department of Public Works and Highways
  Government of the Northwest Territories
  Yellowknife, N.W.T.
  X1A 2L9
  (403) 873-7202

Information on this demonstration project is also available from the consultant:

- Mr. Jack Dueck
  (re: ENEROPTIONS)
  Apsco Engineering Ltd.
  P.O. Box 270
  Cremona, Alberta
  T0M 0R0
  (403) 286-2199